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ABSTRACT

The Individual Mathematics Teaching Project (IMU) has been under development in the upper level (grades 7-9) of the comprehensive school in Sweden since 1964. Its goals are (1) to construct and test self-instruction study material in mathematics, (2) to find suitable teaching methods and work forms for the use of this material, (3) to try out different ways of grouping pupils and making use of teachers in order to achieve maximal effect for the material and methods, and (4) to measure the effects of the individualized teaching (in comparison with conventional teaching). There have been three major revisions of this program resulting from extensive field testing. The present report gives a brief background of the project and results of investigations carried out during the 1968/69 and 1969/70 school years. (JP)

INGER LARSSON

INDIVIDUALIZED MATHEMATICS TEACHING

CWK GLEERUP/LUND

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Individualized Mathematics Teaching

RESULTS FROM THE IMU PROJECT IN SWEDEN

STUDIA PSYCHOLOGICA ET PAEDAGOGICA
SERIES ALTERA XXI

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Contents

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Introduction

During the years 1968—1971 an investigation of effects of individualized mathematics teaching was carried out in the upper level (grades 7—9) of the comprehensive school in Sweden. The investigation was part of the research programme of the project IMU—Individualized mathematics teaching (Sw. *individualiserad matematikundervisning*), which started 1964. Within the investigation of effects lie ten part-studies all of which have been presented and reported in previous reports. These reports have, however, offered only limited opportunities for comparing results from different part-studies or discussing the role of the individual result in the experimental activity as a whole. This report will attempt to give a comprehensive picture of the experiments with individualized mathematics teaching in the upper level of the comprehensive school, in which the IMU material have been used.

The report has three main aims:

1. To give a brief description of the background to the IMU project and the experiments carried out within the framework of the investigation of effects,
2. To summarize briefly the results of the ten part-studies that were included in the investigation of effects,
3. To discuss the results from the point of view of the factors that distinguish the IMU system from other existing study materials in mathematics.

The plan of the report is as follows: first, a short description is given of the work of the IMU project up to the beginning of the investigation of effects, stating the experiments on which the investigation was based. A description of the IMU material, version 3, IMU Upper Level, follows. The investigation of effects was planned during the school year 1967/68 and a preliminary plan of investigation was published during the autumn of 1968. This preliminary plan is presented, together with accounts of the extent to which it has been followed, the deviations from it and the problems that have been studied within the investigation of effects. The summary of each part-study has been placed in Appendix. A summary of so many years' experimental activity in so many

areas, as is the case of IMU, must necessa. · condensed. In each individual case reference is given to the original report(s). In connection with the summary of each part-study, the reliability of the analysed data is given together with the way in which the analyses have been carried out.

The summary of results is presented in the form of a list of points which are intended to cover the main results in question. The main emphasis in the report is placed on a discussion of the results, as stated in point 3 above. Each section within this discussion finishes with a comment which tries to state the extent to which the results obtained can provide answers to some of the questions on which the experimental work was originally based. In the discussion section the following factors are dealt with:

1. Methods
   a. The degree of individualization
   b. Attitudes towards the method
   c. Individualization of rate of work
   d. The alternative courses in mathematics

2. Material
   a. General opinion of the material
   b. Sections requiring revisions and revisions made
   c. The terminal tests

3. The organization
   a. Organizational models during the experimental period
   b. Class size
   c. Disposition of rooms
   d. Teacher density

4. The changed role of the teacher.

1. Background and Aims of the IMU Project

A series of educational reforms has been carried out in Sweden during the post-war period. During the first stage it was mainly a question of external organizational changes. Subsequently these changes led to increasing demands for improvements to be made within the educational establishments involved. Among other things it was requested that within the framework of the established organization new teaching material should be introduced, better study materials made available and other forms of activity complement those commonly occurring. These requests initiated new lines of thought about the organization of the internal work of the school.

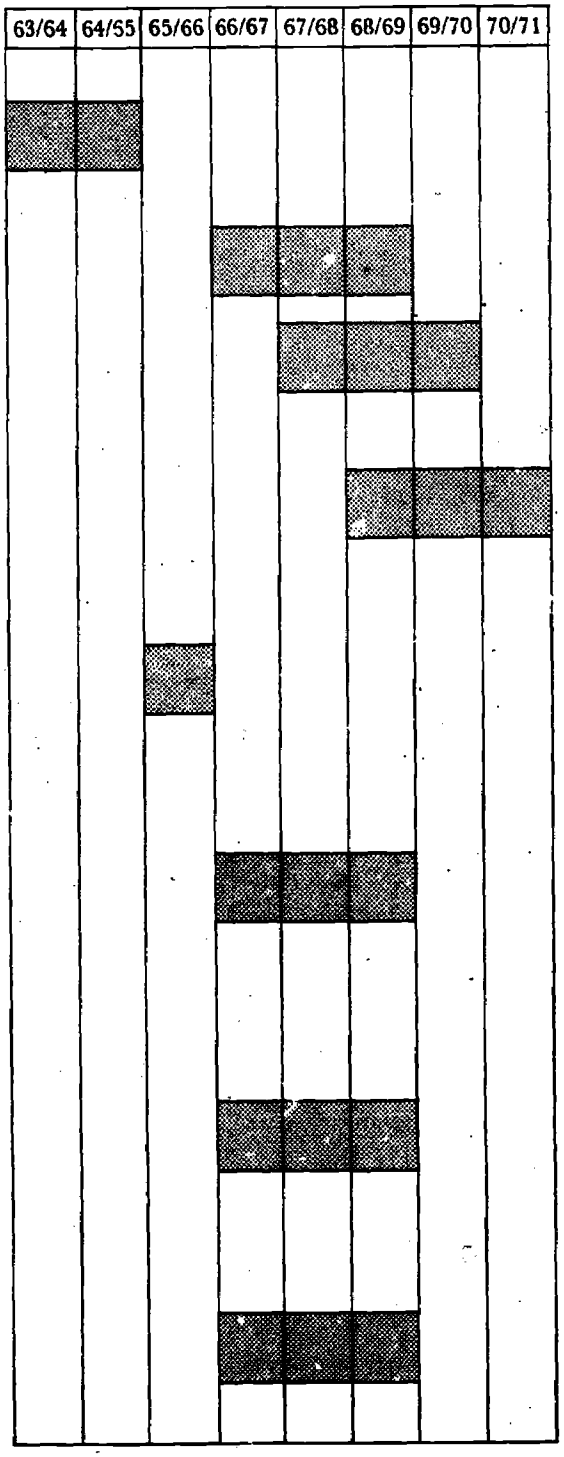
In the general debate on educational problems, the content of the material for the teaching of mathematics and the methods used in the teaching occupied a relatively dominant position. The discussion involved both the comprehensive school and the upper secondary school. In order that mathematics teaching might, if possible, be changed for the better, some experimental activity was initiated. One of the prime movers in this was the Nordic Committee for the Modernization of Mathematics Teaching. A certain amount of this experimental work was planned within the framework of the IMU project.

In the autumn of 1963 a study commissioned by the National Board of Education was set up with the purpose of comparing the effects of completely individualized teaching and conventional teaching in the subject of mathematics in grades 7 and 8. The results of the first year of the experiment were such that it was considered worthwhile to follow up the work. Therefore in the autumn of 1964 the National Board of Education (Section L4) started the IMU project. The original study was incorporated into the project in the form of a preliminary study.

A whole series of experiments has been carried out within the framework of the project, of which one is the investigation of effects. Box 1 presents a summary of the different field experiments, which will be briefly commented upon here.

Field experiment 1 was the preliminary experiment mentioned above, concerning the effects of individualized mathematics teaching. This was carried

Box 1. Field experiments, a summary.



1. Preliminary experiment concerning the effects of individualized mathematics teaching, grades 7—8 (G-county, about 700 pupils)
2. Material testing, version 1, grades 7—9 (Braås, 75 pupils)
3. Material testing, version 2, grades 7—9 (whole country, about 8000 pupils)
4. The experiment concerning the effects of a fully individualized teaching, grades 7—9 (whole country, about 12,000 pupils)
5. Preliminary experiment concerning flexible grouping of pupils and teacher teams, grade 7 (Braås, about 150 pupils)
6. Preliminary experiment concerning flexible grouping of pupils and teacher teams, grades 7—9 (Braås, Lessebo, Strömsnäsbruk, Malmö, Uppsala, Karlstad, Borås, Hultsfred, about 1100 pupils)
7. Preliminary experiment with individualized teaching, flexible grouping of pupils and teacher teams, upper secondary level (Malmö, Göteborg, Växjö, Älmhult, Karlstad, about 1200 pupils)
8. Preliminary experiment concerning the effects of individualized mathematics teaching, grades 4—6 (G-county, Malmö, Ronneby, about 600 pupils)

out in grades 7 and 8 during the school years 1963/64 and 1964/65. During the school year 1965/66 this was supplemented with a preliminary experiment concerning the flexible grouping of pupils and team teaching (field experiment 5) and during the school years 1966/67—1968/69 with an expanded experiment (field experiment 6).

During the school year 1965/66 the production of version 1 of the material was started and the material was then tested, starting with the school year 1966/67 at the school in Braås, with about 75 pupils participating (field experiment 2). This testing of the material resulted in version 2 of the IMU material, which was constructed parallel with the completion of version 1. The material was tested on about 300 pupils in the Växjö district, while a more general collection of data was carried out on all the approximately 8000 pupils and 200 teachers who had been working with this version during the school years 1967/68– 1969/70 (field experiment 3).

The testing of version 2 resulted in version 3 of the IMU material, which is the version used in the investigation of effects (field experiment 4). The investigation of effects started in the school year 1968/69 and was completed 1970/71. It is the results of this experiment that are summarized and discussed in this report.

As can be seen in Box 1, the project has mainly worked with the upper level (grades 7—9) of the comprehensive school. Some preparatory experiments have been carried out in both the upper secondary school and the middle level (field experiments 7 and 8). Both experiments started in the school year 1966/67 and were concluded in the school year 1968/69.

When the project started, the aims with regard to grades 7, 8 and 9 were formulated thus:

- to construct and test self-instructional study material in mathematics
- to test suitable teaching methods and work forms for the use of this material
- to try out different ways of grouping the pupils and making use of the teachers in order to achieve maximal effect for the material and methods
- to measure by means of the material constructed the effects of individualized teaching (in connection with a comparison with conventional teaching).

Thus the aims given above include material, method and organization, the three factors that together form the IMU system.

The experiments that have been carried out in the middle level of the comprehensive school and the upper secondary school cover to a varying extent the three factors mentioned above.

In addition to these field experiments, there is the work that has resulted in the IMU project's goal descriptions for self-instructional study material in mathematics. This work was started in the school year 1965/66 and the goal

descriptions and collection of examples were published in December 1966. The construction of the study material has on all essential points followed the project's goal descriptions as far as the course content is concerned. The goal descriptions have not on the other hand been an important instrument in deciding which areas in the material were to be accentuated.

The measurements that have been carried out in studies prior to the investigation of effects mainly concern achievement tests in mathematics, pupils' and teachers' attitudes towards mathematics, the teachers' workload in IMU teaching and the teachers' opinions of the work form as such. In addition the material testings include analyses of the tasks in the booklets, the diagnostic and prognostic tests and interviews with teachers and pupils about their opinions of the material.

The results from the project's different areas of activity in addition to the investigation of effects have been reported in the following reports and bulletins:

Field experiment 1:
Öreberg, C. IMU-projektet: Rapport från pågående försök. *Pedagogisk-psykologiska problem,* No. 8, 1964.

Individualiserad matematikundervisning. *Kommunal Skoltidning,* No. 5, 1965.

Försök med individualiserad matematikundervisning. *Pedagogiska Meddelanden,* No. 9, 1965. (Also available in off-print from the Department of Educational and Psychological Research in Malmö, No. 12, 1965.)

Field experiment 2:
Öreberg, C. Material för individualiserad matematikundervisning. *Pedagogiska Meddelanden,* No. 7, 1966.

Field experiment 3:
Jivén, L. M. IMU-projektet: Rapport från utprövning av IMU-systemet på grundskolans högstadium (I). *Pedagogisk-psykologiska problem,* No. 63, 1968.

Jivén, L. M. IMU-projektet: Rapport från utprövning av IMU-systemet på grundskolans högstadium (II). Stencilled.

Field experiment 5, 6.
Öreberg, C. Försök med flexibel elevgruppering och lärarlag. *Pedagogiska Meddelanden,* No. 3, 1966.

Field experiment 7:
Jivén, L. M. IMU-projektet: Försök med individualiserad matematikundervisning på gymnasium. Stencilled.

Field experiment 8:
Hellström, L. IMU-projektet: Försök med individualiserad matematikunder-

visning på grundskolans mellanstadium. *Pedagogisk-psykologiska problem,* No. 157, 1972.

The IMU-project's goal descriptions and collection of examples are reported in: *The IMU system. Description of objectives.* The Swedish National Board of Education. Stencilled.

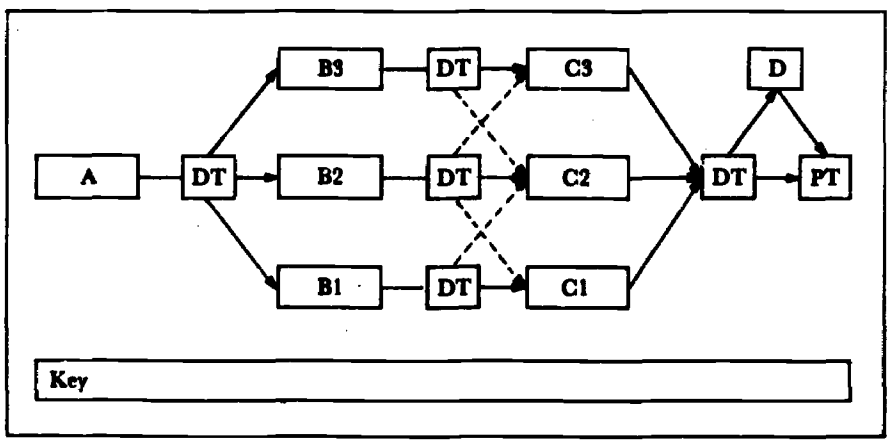
Öreberg, C. (Ed.) IMU-projektet: Målbeskrivning för ett självinstruerande studiematerial i matematik för grundskolans högstadium. *Pedagogisk-psykologiska problem,* No. 43 a, b, 1966.

2. IMU Upper Level—a Description of the IMU Material

Version 3 of IMU Upper Level is the version that has been tested in the investigation of effects.

The principle behind the model for IMU Upper Level is that there should be no grade differentiation and no division into general and special courses. Instead the material is built up of nine units, known as modules, which together cover the upper level course in mathematics. Starting with a common curriculum for all pupils, the subject material is then structured according to the degree of difficulty within each module. Box 2 outlines the principles on which a module is based.

Box 2. **Diagram showing principles of a module in IMU Upper Level—version 3.**



Each module comprises four parts, components, the first three of which belong to the basic course. They are called components A, B and C. Component A is common for all pupils. The B and C components are divided into levels of difficulty, hereafter called booklets. For the B component there are 2 or 3 booklets, called B1, B2, B3 or B1, B2—3. The C component comprises

3 booklets, C1, C2 and C3. The degree of difficulty is easiest in the B1 and C1 booklets, while B2—3 or B3 and C3 are the most difficult. The different booklets cover roughly the same material but the way in which the instructions are presented and the number of extra tasks vary. The D component is not part of the basic course. It exists only on one level and comprises both revision tasks and certain tasks of a more independent nature. Each component except the D component is completed with a diagnostic test (DT). The number of tasks in this test varies depending on which booklet has been studied within the component. As a rule the number of tasks is greater for the more difficult booklets. Each component also includes diagnostic tasks that the pupils correct themselves. Each module finishes with a prognostic test (PT) which exists in three parallel versions.

The material is individualized in both the rate of work and the degree of penetration. As a result pupils within one grade can reach different points in the material. The intended "normal rate of study" is three modules per year.

In principle the pupils are free to choose which booklet they like. The idea is that the pupils should together with their teacher go through what they have achieved earlier and on the basis of this and other experiences choose a suitable level. It is possible and permissable to change level both within and between modules. The constructors of the material have indicated certain figures for guiding the spread between the different levels in a component, but neither pupils nor teachers are obliged to follow these figures.

One of the starting points for the construction of IMU Upper Level has been the project's goal descriptions for a self-instructional study material in mathematics for the upper level of the comprehensive school (cf. p. 15). This goal description comprises 17 areas of material, containing a total of 208 items. The areas are divided into two goal levels: knowledge and proficiency. In the majority of cases the 208 items have been divided into further behavioral units, with the result that altogether the catalogue of goals lists about 700 goal behaviors. The goal description states what the pupils should know when they leave the upper level of the comprehensive school. In order to heighten the precision and communicability of the goals, the concepts expressed by the curriculum as "command", "understand", "be acquainted with", "know about" and "have insight into" have been replaced by terms such as "be able to give examples of", "be able to define", "be able to illustrate", "be able to construct", "be able to give an account of" and "be able to point out". The goal descriptions also include a collection of examples that express concretely the behaviors described verbally in the catalogue of goals. Together with this collection of examples and the study material, the goal description has provided the starting point for the construction of the terminal tests, which have been used to test the knowledge and proficiency of the pupils at the end of grade 9. The terminal tests comprise about 700 separate tasks.

3. The Investigation of Effects

The investigation of effects was planned during the school year 1967/68. The preliminary plan was published in November 1968 (Jivén & Öreberg, 1968 b). It took up seven main points that were to be studied during the three years that the investigation of effects was intended to last. It stated as follows:

"The IMU system will be made the object of evaluation in several respects. This evaluation will be carried out in the period 1968—71, commencing during the autumn term of 1968. During this period comparisons will be made of the following organization models:

a) The Big Class, using IMU material in accordance with the directions prescribed in the manual on methods (Hästad and others, 1968 a).
b) The Single Class, that is to say an ordinary class unit, using IMU material according to the regulations prescribed in the manual on methods with the exception of those applicable to the Big Class.
c) The Standard Class, in which traditional class instruction is given and 'material other than IMU material' is used." (Jivén & Öreberg, 1968 b, p. 10.)

"The intention is to compare in various respects the experimental groups under points a), b) and c). The most important comparisons will naturally be those made between the two groups using the IMU material. Within these, comparisons may also be made on the basis of divisions in terms of variables such as the conditions applicable to achievements or those applicable to attitudes to school subjects and the school situation. Variables connected with organization form another basis for division. The comparison between the big class and the single class will be made in relation to final results, as regards achievements and experiences. It is, however, not feasible, except to a limited extent, to make comparisons between the forms of organization under a) and b), on the one hand, and that under c) on the other, because these groups have courses of a different nature. Comparisons between them must be based on variables concerned with experiences of various kind. To the extent that the contents of the courses are identical, comparisons may also be made on the basis of achievements.

One more essential comparison will be attempted, that of achievements in the groups of pupils using IMU material and the established aims as defined in Öreberg 1966." (Ibid. p. 11.)

The preliminary plan also prescribed the following detailed plan for the investigation of effects:

"1. During the investigation period and at its end, a report is planned to be made of the pupils' knowledge and proficiency
   a) in mathematics (arithmetic tests, standard tests, final test based on the definition of the aim)
   b) in reading ability and study technique
   c) in ability to plan and accept responsibility (independence)
   d) in working together with other pupils as well as with the teacher and assistant assistants (ability to co-operate).

2. The investigation will include an account of the pupils' experience of
   a) the contents of the course
   b) the material
   c) method of working
   d) the organizational form
   e) the school situation.

3. The investigation will also report on the teachers', assistants' and head-masters' experience of
   a) the contents of the course
   b) the material
   c) the method of working
   d) the organizational form
   e) the school situation.

4. The investigation will also report on the effects of rationalisation in regard to
   a) the need for teachers
   b) the need for assistants
   c) problems in drawing up the curriculum
   d) the need for premises
   e) total costs of instruction in mathematics.

5. The investigation will contain a description of the material in question in regard to
   a) the scope of the material and its appearance, legibility, vocabulary and illustrations
   b) analyses of details found in the problems contained in the handbooks
   c) the results of all the diagnostic and prognostic tests, analyses of the details found in the problems and the norms laid down
   d) time available for the various components
   e) the questionnaire on the subject of the pupils' views on various parts of the system, such as mental arithmetic exercises, taped summaries for revision, D components
   f) the questionnaire on the subject of the teachers' and assistants' views on the system
   g) the questionnaire on the subject of the parents' views on the system.

6. The investigation will contain a description of work during lessons in regard to
   a) the activity of the pupils (in detail) during a normal lesson, covering such aspects as the amount of time required to read the handbook, to obtain material, to talk to the teacher, to "take it easy"
   b) the activity of the teachers: analysis of their work, observations
   c) the activity of the assistants: analysis of their work, observations.

7. Psychological, educational or sociological investigations based on material included

in the investigation into the effects, of interest to the school, will be carried out and will cover, among other things

a) investigations of pupils whose performance is poor enough to warrant their inclusion in classes for backward pupils: e.g. a comparison between original IMU material and IMU material in modified form, for instance with altered rates of advancement or without keys
b) investigations affecting classes or individuals with poor eyesight e.g. IMU material in larger type
c) investigations affecting classes for the deaf or individuals with poor hearing
d) investigations concerning classes in reading and writing or individuals having difficulty in reading or writing, e.g. comparison between written or oral presentation of the IMU material
e) investigations into the problems of pupils suffering from anxiety
f) investigations concerning social relations, covering both pupils and teachers, assistants, etc.
g) an investigation designed to follow the pupils' progress in the senior secondary school." (Ibid. pp. 11—13.)

On all essential points this plan has been followed. Individual questions which were placed under certain main headings in the preliminary plan have been moved over to others, however, and some parts have been expanded while others have been reduced. On two points extensive changes have been carried out, in the part-studies that were planned for special classes and in the main investigation during the last school year, that is to say 1970/71 when the pupils were in grade 9. The first change meant that the studies that had been planned for special classes were terminated during the first year of the experiment. The reason was that they would have involved extending the project at least one and perhaps two years beyond the school year 1971/72, which was planned as the final year. The other change meant that the main investigation was terminated after grade 8 and there were several reasons for this. Firstly, the splitting of the pupils between different lines in grade 9 that made it possible for them to choose not to study mathematics led to a reduction in the basic pupil data in grade 9. This reduction was selective in that it was mainly the weak pupils who chose lines without mathematics. Secondly, some complications arose in the production of material during the autumn of 1971, which it was feared would lead to the quickest and cleverest pupils dropping out. Thirdly, the IMU pupils were studying according to the curriculum of 1962 (although not with regard to the content of the course) and they thereby belonged to a form of the upper level school that was to disappear in the school year 1970/71, when the new curriculum came into force. Results from a level with separate alternative lines would be very difficult to compare with an undifferentiated level. Fourthly, as a result of the division into lines in grade 9 many of the pupils moved into new organizational forms. The effects of these changes (new classes, new classmates, new teachers or teacher teams) would be impossible to distinguish from the effects of the work in the IMU

system. The rest of the data were collected, however; the terminal tests, the job-analytical study and the study of the IMU material.

Starting from the seven main points in the preliminary plan, eight part-studies have been carried out. After the project was underway, a further two were added. The ten part-studies within the investigation of effects are:

1. Main investigation. This concerns point 1—4 and parts of point 7 of the preliminary plan. It comprises the groups IMU pupils, IMU teachers and IMU assistants. The groups control pupils and control teachers are also treated marginally.
2. Goal testing study. This concerns point 1 and comprises the group IMU pupils.
3. Material study. This concerns point 5 and comprises the group IMU pupils.
4. Job analysis study. This concerns points 3, 4 and 6 and comprises the groups IMU teachers and IMU assistants.
5. Parent study. This concerns point 5 and comprises a group of the IMU pupils' parents.
6. Observation study. This concerns point 6 and comprises the groups IMU pupils, IMU teachers and IMU assistants, plus the groups control pupils and control teachers (although not the same groups as were used for control in the main investigation).
7. Study of anxious pupils. This concerns point 7 and comprises the groups IMU pupils and control pupils.
8. Studies of different ways of presenting the study material in mathematics. This concerns point 7 and comprises the groups remedial class pupils and normal class pupils.
9. The work of the project consultants within the IMU project. This was not included in the preliminary plan and came about as a result of the consultant work that was started in the project.
10. Study of single pupils. This was not included in the preliminary plan and came about as a result of the work done by the project consultants in following up pupils who moved from an IMU school to schools which did not have IMU at the upper level.

The results from the ten part-studies have been presented in a total of 17 reports, of which three have been published earlier and have therefore not been counted as part of the series of reports from the investigation of effects. Since the summary of the results is based on all the reports, it will first be stated which reports derive from the various studies and a brief description of their contents will be given. All the reports are published in the series *Pedagogisk-psykologiska problem,* Malmö: School of Education.

3.1 Main investigation

The results from the main investigation are presented in three reports (Larsson & Larsson, 1972, Larsson, 1972 a, b). The first deals with the conditions for data analysis and relates the main investigation's populations, samples, measurements, measuring instruments, reliability tests, chosen methods of analysis and the accounting principles for later parts of the results. Certain

organizational factors are also discussed, namely the changes in the organizational milieu that have taken place during the experimental period and the changes that have taken place in the composition of the teacher and assistant groups.

The second report (Larsson, 1972 a) presents the results from the main investigation's pupil study. The account is based on three main types of question:

a) How important are characteristics of the pupils themselves?
b) How important are characteristics in the pupils' milieu?
c) How important are characteristics of the pupils' teachers?

These questions are regarded from the point of view of the pupils' knowledge and proficiency in mathematics, their general attitudes towards school and towards mathematics, their attitudes towards other school subjects, their attitudes towards the IMU material, the IMU method, the content of the IMU course and to IMU in general.

The third report (Larsson, 1972 b) presents the results of the main investigation's teacher and assistant study. The account of the teacher study is based on two main types of question:

a) How important are characteristics of the teachers themselves?
b) How important are characteristics in the teachers' milieu?

These questions are considered from the point of view of the teachers' distribution of working time between different tasks during and outside lessons in connection with IMU teaching and of their attitudes towards the different parts of the IMU system and the changes that teaching with IMU can bring about both for themselves and for the pupils.

The account of the assistant study is based on the following main type of question:

How important is the organizational milieu in which the assistants work for their tasks during and outside lessons in IMU teaching?

3.2 Goal testing study

The results from the goal testing study are reported in Hellström (1972 b). In the introduction and conclusion of the report, some of the problems associated with the use of criteria-related tests are discussed, together with the procedures that have been used in constructing the terminal tests, which are based upon the goal descriptions of the IMU project. The account of the results from the terminal tests is based on three main types of question:

a) What is the total level of the pupils' knowledge and proficiency within the areas defined in the goal descriptions of the IMU project?
b) How important are characteristics of the pupils themselves with regard to knowledge and proficiency as defined in a)?
c) How important are characteristics in the pupils' milieu in the same respect?

3.3 Material study

The results from the material study are described in two reports (Larsson, 1972 c. Davidsson, 1972). The former gives the results for grades 7 and 8, the latter for grade 9. The reports give accounts of the pupils' results in diagnostic tests and prognostic tests, together with their opinions on the different booklets and individual items in the booklets. In addition figures are given for the amount of time used for each booklet and module, the working speed in relation to achievement, the results of the prognostic tests in relation to the level of difficulty, the pupils' choices and routes taken through the IMU material's nine modules, together with some data on how far the different versions of the prognostic tests are parallel.

3.4 Job analysis study

The results of the job analysis study are presented in two reports (Alehamnar & Klasson, 1972 a, b). The former gives job descriptions for principals, heads of department, teachers and assistants and is based on the general question of what tasks and situations those holding these posts have faced in their work with IMU teaching. The latter presents the results of a questionnaire study carried out on heads of department, teachers and assistants and is based on two main types of question:

a) How important are characteristics of the job-holders themselves?
b) How important are characteristics in the job-holders' milieu?

These questions are put with reference to the tasks they are faced with in IMU teaching, the actual and desired relative amount of work needed for each task, the opportunities given for cooperation, the difficulties involved in dealing with the respective tasks and the stimulus given by the respective tasks.

3.5 Parent study

The results of the parent study are reported in Larsson (1972 d). The parents' knowledge of IMU and the new mathematics is described, together with their

attitudes towards individualization and the different organizational models. The report also gives an account of the extent to which the parents may and can help their children with their mathematics and their attitude towards the school their children attend compared to the school they once went to themselves. The parents' answers are related to certain characteristics of the children and to the type of class the children are in.

3.6 Observation study

The results of the observation study are reported in Martinsson (1972). An account is given of some observation studies carried out both in classes working with IMU and in classes working in a conventional way. Some organizational models with high frequencies have been studied and the results are discussed in relation to one main type of question:

How important are different organizational models for the tasks of the teachers, assistants and pupils during the lessons?

The models that have been studied are some three-class models, one two-class model and the one-class model. In addition comparisons are made with some control classes having conventional teaching.

3.7 Study of anxious pupils

The results of the study made of the problems of anxious pupils are presented in Petterson (1972). The report comprises two part-studies. The first attempts to investigate possible connections between on the one hand school motivation and anxiety and on the other sex and achievement variables. The development of both IMU pupils and control pupils has been studied during a period of two years. The second part-study aims at examining possible connections between the ability to see logical connections between numerical exercises and test anxiety, school motivation and attitudes towards mathematics in grades 3, 6 and 9. The second part comprises pupils who do not work with IMU.

3.8 Studies of different ways of presentation

The studies that have been carried out on different ways of presenting mathematical material are presented in three reports (Berglund & Jivén, 1968,

Berglund & Jivén, 1969, Jivén, 1971). They have all three been conducted on groups of pupils other than those working with IMU upper level, version 3. Two main types of problem have been dealt with: the effect of the size of the step in the presentation of mathematical material, both when a teaching machine is used and in a "normal" textbook, and comparisons between visual and auditive presentation of mathematical material. In the first two studies, pupils from remedial classes in grades 5, 6 and 7 have participated, and in the third, pupils from reading classes in grades 4 and 6, from remedial classes in grades 5 and 6 and from normal classes in grade 7.

3.9 The work of project consultants within the IMU project

The work of the project consultants is reported in Olsson (1972 a). The report consists of a collection of notes on general experiences of working as a project consultant and accounts of impressions from the various visits made to schools by the project consultants during the years 1969—1971.

3.10 Study of "single" pupils

(Pupils who have moved from a school using IMU in mathematics teaching to a school that does not have IMU and are allowed to continue working with IMU alone in the new class are here called "single" pupils.) The results of the study of single pupils are presented in Olsson (1972 b). The report discusses the problems of these pupils and the routines that have been developed by the project consultants for solving them both for the pupil and for the new teacher. The report also presents the results from questionnaires given to single pupils in grades 7, 8 and 9 and to the teachers of these pupils.

3.11 Summary of the ten part-studies

Box 3 presents a survey of the ten part-studies. It gives the name of each study as given above, the category(ies) of the people who have participated, the number participating, the number and occasion of measurements and a brief description of the measuring instruments used. All the studies have been carried out during the period spring 1968—spring 1971, that is to say during a period of approximately three and a half years.

Box 3. Survey of the ten part-studies of the investigation of effects.

Study	Category	Number of indiv.	Measur. occasion	Instrument/technique
1. Main investigation	pupils Random sample from the population of IMU pupils of approx. 12,000	1008	August '68	standard tests in mathematics and Swedish marks in mathematics and Swedish attitude schedule
			December '68	marks in mathematics questionnaire
			May '69	achievement tests in mathematics marks in mathematics questionnaire attitude schedule
			December '69	marks in mathematics
			March—April '70	achievement tests in mathematics standard tests in mathematics and Swedish marks in mathematics questionnaire attitude schedule
	teachers	294	December '68	questionnaire
	All teachers who taught with IMU in the experimental classes during the experimental period	295	May '69	questionnaire
		293	March—April '70	questionnaire
	assistants	67	December '68	questionnaire
	All assistants who worked with IMU in the experimental classes	66	May '69	questionnaire
		68	March—April '70	questionnaire

Study	Category	Number of indiv.	Measur. occasion	Instrument/technique
2. Goal testing study	pupils All IMU pupils who studied mathematics in grade 9	8600	May '71	goal tests in mathematics
3. Material study	pupils Random sample from the population of IMU pupils of approx. 12,000	374	Continuously during experimental period 1968—1971	diagnostic tests prognostic tests questionnaires
4. Job analysis study I	school principals teachers assistants	32 40 14	Spring term '69 and Autumn term '69	personal interviews
Job analysis study II	teachers assistants All teachers and assistants who worked with IMU during the school year 1970/71 in grades 8 and 9	358 82	May '71 May '71	questionnaire questionnaire
5. Parent study	parents Parents of the pupils who participated in the material study	364	May—September '71	questionnaire
6. Observation study	teachers assistants pupils All teachers and assistants and a sample of the pupils working at 5 experimental schools and at 3 control schools	19 5 468	school year 1970/71, five observation periods	observation schedule

Study	Category	Number of indiv.	Measur. occasion	Instrument/technique
7. Study of anxious pupils I	pupils		September '68	intelligence test
	Random sample of IMU pupils	649 (IMU)		marks in mathematics
	and a group of control pupils	839 (control)		school motivation test
				anxiety scale
			March—April '70	school motivation test
				anxiety scale
Study of anxious pupils II	pupils	96	October '70	achievement test in mathematics
				marks in mathematics
				school motivation test
				anxiety scale
				attitude test
8. Study of different ways of presenting mathematical material	pupils	449	Spring term '68 to spring term '71 (Seven occasions)	intelligence tests
	Seven small part-studies of pupils not normally working with IMU			achievement tests
9. Work of project consultants	principals		Continuously during the school years 1969/70 and 1970/71	personal interviews
	teachers			visiting diaries
	assistants			
10. Study of single pupils	pupils	80	Spring term '70	questionnaire
		154	Spring term '71	questionnaire
	teachers	60	Spring term '70	questionnaire
		76	Spring term '71	questionnaire

4. Basis for Interpretation and Discussion of Results of the Investigation of Effects

Sections 5—9 present a discussion of the main results that have been obtained from the investigation of effects. Those who wish for detailed information about any of the part-studies while reading are referred to Appendix 1. This contains brief summaries of certain background information and of the main results. The background information concerns the reliability of the data that have been analysed and the methods of analysis that have been used in each individual case. In the Appendix the results are expressed in a series of "that" clauses. When reading the discussion section and the Appendix, certain factors should be taken into consideration.

1. Since the investigation of effects started during the school year 1968/69, the pupils in grades 7—9 were following the curriculum of 1962. This did not apply to the IMU pupils, however, as far as the *course content* was concerned. The contents of the IMU course were adapted to the new curriculum that was about to come into force. This difference in course content makes it impossible to compare IMU pupils with other pupils in grades 7—9 during the experimental period. (In practice it will not be possible to compare IMU pupils with other pupils until both groups are working in accordance with the same curriculum, which in the case of grade 9 will not happen before the spring term 1973.) It also means that the tests that have been given to the IMU pupils have been constructed within the project and have only been tried out on IMU pupils. Some standard tests for grade 8 have been given to both IMU and control pupils, but no unequivocal interpretations of similarities and differences can be made. Thus all that is said here about knowledge and proficiency, about the attitudes and opinions of the pupils, applies only *within IMU*.

2. As a result of the adaptation of the IMU course content to the curriculum of 1969, both teachers and pupils are to some extent faced with new mathematical material. For the pupils this means that when they start in grade 7 they must get used to somewhat different terminology and a somewhat dif-

ferent accentuation within the various areas than they were accustomed to in the previous grades. The teachers have in their turn needed extra training, in addition to the readjustment required for working with the IMU methods and organization. The teachers have had to read up the entire study material and be at least one module ahead of the fastest pupil (this possibly does not apply to the teachers who worked with version 2 of the IMU-material at an earlier stage). The main investigation's teacher study provides information about the amount of time needed by the teachers for studying the method manual, teacher instructions and the pupils' booklets. This offers some possibility of clarifying the work-load that the new course content can have caused. But since no corresponding data have been collected from other teachers, working with study material other than IMU, it is not possible to state exactly how much extra work the teachers may have had because of the new course content.

3. Like the composition of the teacher teams, the organizational pattern changed so much while the experiment was underway that no analyses over several measurement occasions could be made. This means that for both the pupil and the teacher/assistant studies in the main investigation, analyses have been carried out per term. Any statements made about changes or lack of changes are not based on statistical analyses.

4. Some of the part-studies included in the investigation of effects are based on samples, others are population studies. The former applies to the main investigation's pupil study, goal testing study, material study, parent study, part I of the study of anxious pupils (random samples), part II of the study of anxious pupils, the studies of different ways of presentation, part I of the job analysis study and the observation study (non-random samples). The main investigation's teacher/assistant study, part II of the job analysis study and the study of single pupils are population studies (cf. Box 3).

5. In the main investigation's teacher study and the job analysis study, the group of teachers participating are probably not representative of mathematics teachers in grades 7—9 in general. (In consequence they have been regarded as population studies as above.) Unfortunately the data to be found in official statistics are taken across the grades and across the different school levels, which makes comparisons of IMU teachers with other teachers relatively pointless. It would appear to be a reasonable assumption that teachers who have chosen to participate in experimental activities are more positive towards such activities than other teachers. This might not apply to teachers who came to the IMU schools after the experiment had started, but it is probably true to a greater or lesser extent of the teachers who took part from the start. The only data that admit comparisons between IMU teachers and the teachers

working in control classes are the age of the teachers and the relative mobility (teachers moving from the schools in question). IMU teachers are on an average somewhat older than the control teachers and the relative mobility is smaller among IMU teachers than among the control teachers.

6. Finally it should be mentioned that the main part of the data in the different part-studies has been analysed via ANOVA (*An*alysis *o*f *va*riance). The criterion of difference between the groups consists of the effect size index ω^2 (Hays, 1963, p. 324 ff. and pp. 406—407). This index states how great a proportion of the total variance is represented by differences between means. In order for a difference to be counted as being essential, ω^2 must be at least 0.05, that is to say the differences between means must represent at least five per cent of the total variance. Therefore the terms "significance" and "significance testings" occur very seldom in the different part-studies.

The reason for taking ω^2 as the criterion of difference is that the number of people involved in most of the part-studies is very large, which means that one can easily get significant F ratios without the differences being of any educational interest.

When it comes to the population studies, all the differences are actual differences. But here too the ω^2 criterion has been taken as a basis for discussion of essential differences.

The effect size 0.05 represents what Cohen (1969, p. 277 ff.) calls an effect of average size. This description is exaggerated, however—five per cent of the total variance can rather be considered a small effect.

The discussion of the results of the investigation of effects will be based on factors that particularly distinguish the IMU system from other teaching material in mathematics. IMU's most distinctive feature is revealed in its name: Individualized mathematics teaching. The general purpose of the investigation of effects is "to measure by means of the material constructed (self-instructing study material in mathematics) the effects of individualized teaching". Further distinguishing marks appear as a result of and to some extent as a means to individualization. The study material is not divided according to grades, instead the principle of individualization of rate of work applies. There is no division of the study material into special and general courses, either, so that the pupils work in a unified class, in which organizational division into alternative courses is not needed. These factors in their turn make it possible to group the pupils flexibly and to make use of teacher teams, that is to say, they make it possible to have other organizational arrangements than the conventional one class—one teacher. In addition to these factors there is the material and to an even greater extent the goal descriptions and the terminal tests that are linked to the goal descriptions and material.

The investigation of effects has examined the following questions concerning the distinguishing features of the IMU system:

Method

What degree of individualization does use of the IMU material give with regard to goals/course, instructions, exercises, working methods/rate of work and evaluation and setting of marks? (Cf. section 5.1.)

What is the attitude towards the individual method of working?

What are the consequences of the individualization of the rate of work?

What are the consequences of giving up the organizational division into alternative courses?

Material

How has version 3 of the IMU material functioned?

What level of knowledge and proficiency have the pupils reached at the end of grade 9, measured by the terminal tests that were constructed on the basis of the goal descriptions and the material?

Organization

What teaching units apart from one class—one teacher have been used?

How have these other teaching units been composed, with regard to the size of the pupil groups, the disposition of rooms and the composition of the teacher teams?

Is it possible to work with a lower teacher density; with or without the help of assistants?

Role of the teacher

In what ways, if at all, does the role of the teacher change in individualized mathematics teaching?

5. Methods

5.1 Degree of individualization

One of the premisses for the construction of the IMU material—irrespective of version—has been an attempt to define individualized mathematics teaching (Håstad et al., 1968 a, pp. 8—10). The definition is shown in box 4.

The method manual states the desired degree of individualization with regard to *goals and course:*

"the fact that the pupil participates in setting the goals and planning the work and thereby not only sees the goals clearly but feels them to be his own personal goals should lead to better motivation and more purposeful work. The reason why we are not attempting to achieve total individualization in the planning of goals and syllabus is that the demand made in the curriculum for individualization is balanced by the demands for an extended common frame of reference."

The actual degree of individualization used is very close to the desired level. The number of routes through IMU's nine modules are legion. In principle it is possible for the pupils to choose their level not only between components but also within them, so that some sections are taken from a lower level, others from a higher one. In practice, however, individualization has not been pressed so far. According to the data of the material study, the pupils work right through a level that they have chosen (or been advised to choose). Thus in that respect IMU admits a greater degree of individualization than has been utilized. Individualization is not only made possible by the choice of different levels and the different goals that exist for them, however, since within the material sections can be shortened or expanded through the intervention of the teacher and this is in fact what has happened. The pupils have also to a great extent been given the opportunity of controlling their choice of level themselves, as can be seen in Table 1. The table shows the pupils' answers to the question: "What happened when you got the booklet you are working on now?"

Box 4. Individualized mathematics teaching: An attempt to definition.

Total individualization			No individualization
1. The work of each pupil is directed at achieving a goal that is adapted to his particular ability and interests. Thus each pupil follows his own course, which develops gradually as the teacher plans for each pupil individually. In setting up goals and planning the teacher and pupil confer.	⟵	Goals Course	⟶ The same for all pupils. The teacher plans for the class as a whole. The pupils do not participate in planning or setting up goals.
2. Instructions are given to one pupil at a time. The instructions are shaped by what the teacher knows about the pupil's ability and modified according to the pupil's questions and answers.	⟵	Instructions	⟶ All pupils are given the same instructions. The instructions are not influenced by the pupils' reactions. "Lecturing." Singletrack study material.
3. The number of tasks and their degree of difficulty varies from pupil to pupil. The teacher chooses tasks for one pupil at a time.	⟵	Tasks	⟶ All pupils work with the same tasks. The teacher chooses tasks for the whole class.
4. Each pupil works at his own rate and with methods and material that suit his ability. The pupil "steers" his work himself. The teacher functions as a tutor.	⟵	Methods and Rate of Work	⟶ The pupils are "steered" by the teacher and all work at the same rate and in the same way.
5. The teacher evaluates the work of each pupil on the basis of the pupil's ability. This means that the pupil's achievements are compared with the goals on which the teacher and the pupil have agreed. The marks refer to the goals. The pupil is given a chance to evaluate his work himself. There is no comparison between pupils.	⟵	Evaluation Marking	⟶ The teacher evaluates the work of the pupil by comparing his achievements with those of the other pupils. Then the achievements of the pupils are ranked and they are given marks according to certain norms. The marks refer to the norms. No consideration is taken to the prerequisites of the pupils in evaluating their achievements.

The points on the arrows indicate planned degree of individualization.

Table 1. Pupils' choice of booklet, spring 1970, grade 8.

Alternatives	no.	%
I chose it myself	401	39.8
I talked to the teacher and then chose it myself	229	22.7
I talked to the teacher and then he/she chose it for me	62	6.2
The teacher chose it for me	222	22.0
Other alternatives	94	9.3
Total	1008	

63 per cent of the pupils say that they chose the booklet themselves, 23 per cent after having spoken to the teacher. 28 per cent say that the teacher chose the booklet, 6 per cent after having spoken to the pupil, and the remaining 9 per cent gave other alternatives which mainly consist of the answer "was to have Booklet A", which makes the question of who chose insignificant.

The desired degree of individualization with regard to *instructions* is:

"if the same instructions are to be given to several pupils, the teacher should make use of group teaching. Group activities can also be valuable from the point of view of motivation. Thus the aim should not be to achieve total individualization here, either."

The actual degree of individualization can be said to be greater than the desired degree. Data from both teachers and pupils show that group teaching and group activities occur less frequently than was intended, not least as a means of creating motivation.

On the subject of the *distribution of tasks*, the method manual gives total individualization as the aim.

The actual degree of individualization cannot be said to be total. Since the pupils choose certain levels within the components, either themselves or in consultation with a teacher/teacher assistant or is directed by a teacher, the tasks will vary both in number and degree of difficulty. The difficulty of the material is not so highly individualized, however, as the rate of working. This is connected with the fact that the material has been constructed "from above", that is to say the highest level has been taken as the starting point and from there the lower levels have been constructed by means of elimination or expansion of tasks. It is possible that to achieve total individualization it would have been better to work in the opposite direction. What has been said above under the heading "Goals and course" about the routes that the pupils can take through IMU is also applicable to the distribution of the tasks.

Concerning *methods and rate of work*, the method manual states as follows:

"if the pupil is quite clear as to the goal and if he is equipped with aids that enable him to evaluate his achievements continuously, it should be possible to train him to direct his studies himself. Teaching him this is in itself a goal, but the self-direction should also lead to more effective work. Who knows best which is the optimal rate of work, how much repetition is necessary and so on? Often it is probably the pupil himself."

The actual degree of individualization probably approaches the total level for certain groups of pupils, at least as far as rate of work is concerned. For quick pupils the individualization of the rate of work has been as good as total, but for the slower pupils, however, the freedom to choose methods and rate of work themselves has had to be limited in order to prevent the spread of the material becoming too great, that is to say allowing too many pupils to lag behind in the material.

Finally *evaluation and marking* have been discussed in the method manual:

"School marks have two functions

a) to stimulate the pupil during his education and facilitate his and the teacher's planning of his future studies. These purposes are best served if the marks are related to the goals. Goal-related tests and mark-setting based on such tests mean that the pupil is always competing with an opponent of equal merit (himself). This should stimulate all pupils into making greater achievements in their work. Tests related to norms are of little help in planning and are probably in the long run only stimulating for the *best pupils.*

b) to serve after the completion of the education as an instrument of selection. As far as the comprehensive school is concerned, marks need only be given for this purpose at the end of grade 9. Even as means of selection, a full description of the pupil's achievements in his school work, based on goal-related tests, should be preferable to the norm-related marks we use now. These provide only an approximate ranking of the pupil's achievements."

The actual degree of individualization with regard to evaluation and marking has been at the end "no individualization". Only norm-related marks have been used. Setting of marks are made in reference to course choice although no division is made of common and special course in the teaching situation.

Thus, as it has been used so far, IMU cannot in any respect be said to be totally individualizing, but it permits in theory a very high degree of individualization in some cases and less in others. When it comes to the setting of marks, however, IMU cannot be regarded in isolation, since that kind of individualization does not yet exist within the teaching of mathematics in the upper level of the comprehensive school in Sweden.

5.2 Attitude towards the method

The views of both pupils and teachers on the method have been studied in several respects within the main investigation and the job analysis study. Since the method is an overall factor in IMU, it is not possible to differentiate completely between certain variables that only concern the method and others that do not concern it at all. Some more general questions have been put to both pupils and teachers, however, in connection with the method and the attitude towards it. Later sections will deal with the method from more special angles, but here the general attitude will be described.

5.2.1. *The attitude of the pupils*

In the main investigation's pupil study, there is a variable area that has been defined as "attitude towards the IMU method". The results there show acceptance of the method of working individually: in some cases the pupils express a positive attitude, in others they are neutral. The only point on which they express clear discontent concerns the amount of group teaching they receive. This is only half as much as they would like, as can be seen from Tables 2 and 3. Questions on the desired and actual proportion of group teaching have been asked on three occasions: in the autumn of grade 7, in the spring of grade 7 and in the spring of grade 8. The answer alternatives given were to some extent worded differently and for this reason the answers from the autumn of grade 7 are reported separately from those received in the springs of grade 7 and grade 8.

Table 2. Actual and desired proportion of group teaching, autumn grade 7.

Alternatives	Actual		Desired	
	no.	%	no.	%
every lesson	13	1.3	18	1.8
one lesson a week	38	3.8	174	17.3
one lesson every other week	45	4.5	181	18.0
one lesson a month	425	42.2	372	36.9
I have not taken part in (do not want) group teaching	487	48.3	263	26.1
Total	1008		1008	

Table 3. Actual and desired proportion of group teaching, spring grades 7 and 8.

Alternatives	Spring grade 7				Spring grade 8			
	Actual		Desired		Actual		Desired	
	no.	%	no.	%	no.	%	no.	%
every lesson	13	1.3	27	2.7	19	1.9	28	2.8
every other lesson	11	1.1	23	2.3	6	0.6	30	3.0
one lesson a week	49	4.9	224	22.2	51	5.1	223	22.1
one lesson every other week	72	7.1	146	14.5	65	6.4	130	12.9
one lesson a month	135	13.4	217	21.5	130	12.9	255	25.3
less than one lesson a month	376	37.3	121	12.0	425	42.2	112	11.1
I have not taken part in (do not want) group teaching	352	34.9	250	24.8	312	31.0	230	22.8
Total	1008		1008		1008		1008	

From the point of view of ability and interest there are very few differences between the different groups of pupils. Those that do exist refer to the help they need from the teacher and show that low-achievement pupils need to ask for help more often than the average or high-achievement pupils. All the categories of pupils are dissatisfied with the amount of group teaching. The majority of pupils wish however to continue with IMU. When asked "Do you want to continue working with IMU next term/school year?", the IMU pupils answered as is shown in Table 4.

Table 4. The desire to continue working with IMU.

Alternatives	Autumn grade 7		Spring grade 7		Spring grade 8	
	no.	%	no.	%	no.	%
Yes, definitely	401	39.8	334	33.1	205	20.3
Yes, I think so	526	52.2	505	50.1	522	51.8
No, preferably not	59	5.9	114	11.3	148	14.7
No, definitely not	22	2.2	55	5.5	81	8.0
I am not going to study mathematics next year					52	5.2
Total	1008		1008		1008	

Thus 92 per cent wished to continue after one term, 83 per cent after two terms and 72 per cent after three terms.

5.2.2. *The attitude of the teachers*

The main investigation's teacher study shows that the method has both positive and negative consequences for teachers as well as pupils. The basic attitude towards individualized mathematics teaching is relatively positive. One of the questions put to the teachers was: "What is your attitude towards individualized teaching in mathematics?" Seven answer alternatives were given, ranging from "very positive" to "very negative" with the two poles verbally anchored. The answers can be seen in Table 5. The question was put in the springs of grade 7 and grade 8.

Table 5. Teachers' attitude towards individualized teaching in mathematics.

Alternatives	Spring grade 7		Spring grade 8	
	no.	%	no.	%
very positive (1)	30	11.4	21	8.0
2	87	33.0	85	32.3
3	66	25.0	71	27.0
4	32	12.1	42	16.0
5	22	8.3	25	9.5
6	22	8.3	12	4.6
very negative (7)	5	1.9	7	2.7
Total	264		263	
Mean	3.06		3.11	
Standard deviation	1.51		1.42	

In some respects the teachers' own work-situation changed for the worse, but these changes do not seem to have been so great as to have been felt on an average to be clear disadvantages. Cooperation between teacher and pupils becomes better in certain respects, in others no change has been noticed.

The individual method of work is felt to favour the high-achievement pupils, but to some extent to disfavour the weaker pupils, who are thought to become more dependent on the teacher. The work-situation of the pupils changes both for the worse and the better. There is a clear declaration of discontent concerning the formal treatment in mathematics and oral explanations, which are thought to deteriorate considerably with the individual method. In this connection three questions have been put to the teachers, in the form of statements with seven answer alternatives (the pupils get more training in talking mathematics with IMU—the pupils get less training . . ., the formal treatment

deteriorates with IMU—the formal treatment improves . . ., the pupils get less training in understanding oral explanations of mathematics with IMU—the pupils get more training . . .). All the questions have been asked on two occasions: the spring in grade 7 and the spring in grade 8. The teachers' answers are shown in Tables 6—8.

Table 6. The pupils' training in talking mathematics with IMU compared to conventional mathematics teaching (according to teacher opinions).

Alternatives	Spring grade 7		Spring grade 8	
	no.	%	no.	%
much greater (1)	3	1.2	5	1.9
2	7	2.7	5	1.9
3	7	2.7	11	4.3
4	15	5.8	14	5.4
5	19	7.3	23	8.9
6	61	23.6	50	19.5
much less (7)	147	56.8	149	58.0
Total	259		257	
Mean	6.13		6.08	
Standard deviation	.36		1.29	

Table 7. The formal treatment in mathematics with IMU compared to conventional mathematics teaching (according to teacher opinions).

Alternatives	Spring grade 7		Spring grade 8	
	no.	%	no.	%
much worse (1)	82	31.5	73	28.5
2	65	25.0	54	21.1
3	29	11.2	51	19.9
4	51	19.6	48	18.7
5	17	6.5	17	6.6
6	16	6.2	13	5.1
much better (7)	0	0.0	0	0.0
Total	260		256	
Mean	2.63		2.69	
Standard deviation	1.55		1.47	

Table 8. The pupils' training in understanding oral explanations of mathematics with IMU compared to conventional mathematics teaching (according to teacher opinions).

Alternatives	Spring grade 7		Spring grade 8	
	no.	%	no.	%
much less (1)	118	45.0	104	40.5
2	82	31.3	88	34.2
3	40	15.3	41	16.0
4	16	6.1	15	5.8
5	4	1.5	5	1.9
6	1	0.4	4	1.6
much greater (7)	1	0.4	0	0.0
Total	262		257	
Mean	1.90		1.99	
Standard deviation	1.07		1.11	

The differences that exist between different groups of teachers are often connected with the organizational model they are working with (see more below, section 7).

The job analysis study confirms what both the pupil and teacher studies showed, namely that there is dissatisfaction with the amount of group teaching available. The study also shows the stimulation felt by the teachers when they are given the chance of group teaching or of going through something with the whole (or parts of the) class as a contrast to the individual tutoring and as a means by which the teachers can conduct more formal teaching. The teachers also find it stimulating, however, to go round the class and "sit with pupils who need help".

The attitude towards the method, individualized mathematics teaching, in general, shows acceptance by both teachers and pupils. Some modifications are desired, however, modifications that point towards a somewhat lower degree of individualization (cf. p. 35). To some extent measures have already been taken to this effect. In version 5 of the IMU material, which came into use during the school year 1970/71, special consideration has been paid to the desire for increased group teaching by the insection of a G component in the material. This contains special group teaching sections and is intended to direct the group teaching both in content and proportion to a greater extent than in version 3. How far it will be possible to correct what the teachers think is an inability to listen to and talk mathematics by means of group activities

will not be known until studies have been carried out around version 5. The purely practical possibilities (difficulties) of arranging group teaching is another factor that must be taken into account.

5.3 Individualization of rate of work

The IMU material is strongly individualized as far as the pupils' rate of work is concerned. As a result the spread among the pupils gradually reaches considerable proportions. This spread can lead to a situation in which at the end of grade 9 some pupils are working with study material intended for the upper secondary school, while others have still not finished module 6 (according to the "normal rate of study", this is what the pupil should accomplish during grades 7 and 8). The individualization of the rate of work has been discussed in several of the part-studies of the investigation of effects.

5.3.1. *Effects on the pupils*

The data of the material study show that at the end of grade 8 approximately 60 per cent of the pupils could be said to have kept up the normal rate of study of three modules per school year. Only 46 per cent, however, could be defined as having completely finished module 6. At the end of grade 9, 53 per cent had completed the course for the upper level of the comprehensive school or were at the end of module 9. It was the same here, however, that only 46 per cent could be said to have completely finished. Furthermore it should be noted for grade 9 that some groups of pupils, predominantly those who were weak in the subject, had chosen not to study mathematics.

Table 9 shows where the pupils were in the material at the end of grade 8 and at the end of grade 9. According to the "normal rate of study", the pupils should then have reached the end of module 6 and module 9 respectively.

The material study also reports studies of the connection between working speed and achievement for all the grades concerned. For grades 7 and 8 there is little or no connection between speed and achievement, the few correlations that can be traced (max. 0.24) hinting that the better the achievements are in the prognostic test, the faster the pupil works through a module. For grade 9 the slight correlations that exist for some modules imply that the better the results in the prognostic tests are the longer a pupil takes over a module (max. 0.26). The latter result can possibly be explained by the fact that the pupils in grade 9 are more concerned than those in grades 7 and 8 to get a good final mark. Admission to the upper secondary school is based on marks and for some lines at least there is considerable competition.

Table 9. Point reached by the pupils in the material.

Pupil has reached module/component	End of grade 8			End of grade 9		
	no.	%		no.	%	
3A	1	0.3				
3B	2	0.6	1.2			
3C	1	0.3				
4A	5	1.5				
4B	4	1.2	3.9			
4C	4	1.2				
5A	34	9.9				
5B	13	3.8	17.2			
5C	12	3.5				
6A	53	15.4		1	0.4	
6B	23	6.7	32.3	2	0.8	1.6
6C	35	10.2		1	0.4	
7A	110	31.9		5	2.0	
7B	25	7.3	43.6	3	1.2	3.6
7C	15	4.4		1	0.4	
8A	6	1.7		18	7.1	
8B				3	1.2	10.7
8C				6	2.4	
9A	1	0.3		41	16.1	
9B				37	14.6	37.8
9C				18	7.1	
Upper level course completed				118	46.4	
Total	344			254		

Among the variables that concern the working method, there are none that directly refer to the individualization of working speed. On the other hand some pupils have themselves stated opinions on their work. One of the most dominant reasons for being pleased with one's work is said to be "Organization of tests", that is to say the pupils react positively to getting prognostic tests as soon as they have completed a module, without having to wait until their slower classmates have also finished. Among the reasons they give for wanting to continue with IMU, the individual rate of work and the individual method of work can be noted as indicating a positive attitude to the individualization of working speed (no pupil has given these factors as reasons for not wanting to continue with IMU). The same factors are stated among the reasons why mathematics has become more enjoyable in grade 7 than it was in grade 6. Nobody has used them, either, as reasons why mathematics has become more boring. When the pupils' statements as to the three most/least advantageous factors connected with IMU have been summarized, the individual method of working is also mentioned in the former category. It should

be noted, however, as with all the opinions reported here, that some pupils did not answer the questions.

5.3.2. *Teachers' views on the individualization of working speed*

On two occasions in the main investigation the teachers were asked for their opinions as to why some pupils lagged behind in the material. At the end of grade 7, 43 per cent of the teachers stated that they had no pupils who had lagged behind, but in the middle of the spring term of grade 8 the corresponding value was 21 per cent (i.e. no pupil in the teacher's teaching unit could be said to have lagged behind). The teachers who did have pupils who had got behind with the work primarily gave reasons connected with the pupils themselves: inability to work independently was the most common answer. On the other hand, few reasons were given connected with a lack of opportunity for the teacher to hurry along pupils who worked very slowly. Table 10 shows the proportion of markings for each one of the twenty reasons for lagging behind in the material that the teachers have been able to choose between.

Table 10. Reasons for pupils lagging behind in the material. Proportions for each individual reason. Total teacher group.

Reasons	Spring term '69		Spring term '70	
	prop.	rank.	prop.	rank
all have completed module 2 (4), component B (C)	0.43		0.21	
lack of intelligence	0.36	4.5	0.53	6.0
reading and writing difficulties	0.39	2.5	0.56	3.5
lack of study techniques	0.22	11.0	0.43	9.0
lack of ability to take initiative	0.28	8.0	0.43	9.0
lack of interest in mathematics	0.36	4.5	0.56	3.5
difficulties in planning work	0.15	15.0	0.26	16.0
lack of initial knowledge	0.08	20.0	0.19	18.5
inability to work independently	0.43	1.0	0.58	1.0
lack of opportunities for teacher to initiate work	0.13	16.0	0.27	15.0
lack of opportunities for teacher to check work	0.11	19.0	0.28	14.0
lack of opportunities for teacher to help pupils	0.20	12.0	0.30	12.0
laziness during lessons	0.32	6.5	0.55	5.0
lack of maturity	0.26	9.0	0.29	13.0
dislike of working alone	0.19	13.0	0.40	11.0
general dislike of going to school	0.25	10.0	0.47	7.0
illness	0.17	14.0	0.19	18.5
difficult home conditions	0.12	17.5	0.21	17.0
started using the material late	0.12	17.5		
lack of ability to concentrate	0.39	2.5	0.57	2.0
works only under supervision	0.32	6.5	0.43	9.0

When the teachers in the main investigation were also asked to give positive and negative features of the IMU teaching, the opportunities for the pupils to work at their own speed and the individualization in general were pointed out as positive features, but very seldom as negative ones.

The reports from the project co[illegible] show that the teachers have brought up the problem of planning t[illegible] and have admitted to difficulties in giving the pupils a satisfactory timetable for their work. This has primarily occurred, however, before the teachers have themselves had time to go through the material. It is obvious that during the latter part of the experimental period, the pupils' rate of work has been controlled more rigidly. At some schools a minimum rate of work was introduced for the pupils who worked slowly. On the other hand there appears to have been no attempt to assert any control in the other direction—the pupils who work quickly have only been held back in a few extreme cases.

In Part I of the job-analytical study, some situations are noted with regard to the individualization of the working speed. The teacher assistants compile data on where the pupils have got to in the material and pupils working very slowly are then discussed at the teacher team conferences. During the preliminary training period, the teachers go through a certain amount of study technique with the pupils. During lesson-time situations are stated that concern the pupils' rate of work, such as hurrying along pupils who work slowly and slowing down pupils who work too fast and carelessly. Quick and clever pupils are given extra tasks.

In Part II of the job-analytical study, some of the situations that had emerged in Part I are evaluated. The discussions during teacher team conferences about both fast and slow-working pupils provide one example. Discussions of the latter take most time relatively speaking. Work with both fast and slow workers causes some difficulties for the teachers and they find that this work gives very little stimulation. During lesson-time the teachers devote more time to hurrying along slow pupils than they really wish to do and they experience difficulties here too. In setting marks, maintaining a balance between quantity and quality can give rise to problems, that is to say setting marks for pupils that have equally good (bad) results, but that have completed different amounts of the material.

5.3.3. *Miscellaneous*

Both positive and negative consequences of the individualization of working speed have emerged when contact has been made with the experimental schools after the investigation of effects was completed in the spring 1971. One problem to which attention has been drawn concerns the pupils who during the upper level of the comprehensive school worked through the mathematics course of the upper level and all or parts of the course for the upper

secondary school (gymnasium). It has then happened that when these pupils have gone on to the upper secondary school the mathematics teacher there has refused to accept the marks set on the pupil's knowledge of the more advanced course and also refused to let the pupil continue working on his own from the point where he stopped in grade 9. This situation must have been frustrating both for the pupil and for his former teacher. On the other hand the opposite has also happened—that is to say, that the IMU pupil has been allowed to continue on his own in the upper secondary course directly from where he left off in grade 9 and in some cases pupils still attending the upper secondary school have been able to continue at university level.

Another consequence of the individualization of working speed *and* the existence of alternative courses with regard to setting marks has been that pupils who chose the special course but did not finish the upper level course have been permitted to continue in the upper secondary school in lines demanding special course to which pupils who chose the general course and did complete the upper level course have not gained admission.

Thus there are both positive and negative sides to the individualization of working speed. Possible ways of remedying the negative features are, for example, introducing a restriction on the degree of individualization "downwards", in other words to introduce a minimum rate of work. In each individual case it ought also to be possible to decide whether the working speed can be increased (the spread in the material lessened) by cutting down the material. Difficulties can, however, arise when these reductions cause the desired common frame of reference to be broken. A goal analysis has been carried out in Sweden on low-achievement pupils and it will no doubt be instructive on this point (Basfärdigheter i matematik, 1973). Restrictions of the degree of individualization "upwards", slowing down pupils who work quickly even if they at the same time achieve a high standard, would seem to be an unfortunate solution. Cooperation with the upper secondary school's mathematics teachers is necessary, however, in order that situations similar to those described above may be avoided. The point reached by the pupils in the material must also be taken into consideration, in particular in cases where pupils have chosen the special course but not completed the upper level course when they come to the upper secondary school and then choose lines with mathematics in which it is necessary to have the special course from the upper level.

5.4 The alternative courses in mathematics

The proposition that the National Board of Education handed to the Ministry of Education in November 1967 concerning revision of the curriculum for the

comprehensive school (Läroplansöversyn. Grundskolan. Skolöverstyrelsen. 1967). contained a suggestion that streaming in mathematics in the upper level should cease. Among other references was one to the results obtained within the IMU project. Several reasons were given for abolishing different courses in mathematics: the Board considered that the advantages would be considerable. such as a more closely knit class, simplified organization and greater opportunities for mathematics teachers to function as class teachers. In addition it was pointed out that the proposition would lead to a reduction in the number of teachers required, thus saving money. The Ministry of Education refused this request, however, stating that further information on the matter was needed before a decision could be made for or against giving up alternative courses in mathematics. Therefore the division into general and special course was retained in the 1969 curriculum for the comprehensive school.

No organizational division into general and special courses has been made in the work with IMU. This means that irrespective of which course they have chosen the pupils work in the same class unit. Marks have been set according to the choice of course, however, irrespective of which levels the pupils have chosen to work on and to some extent irrespective of how far they have reached in the material.

The schools have been provided with norms from the project to be used in setting marks. These have been calculated on a sample of the pupils whose prognostic tests have been sent in and corrected centrally.

The problem of alternative courses has been looked into in the investigation of effects by means of studying all the pupil data (knowledge; attitudes, working routine in the material) from the point of view of the pupils' choice of course. It should be remembered that this problem has only been studied *within* IMU.

5.4.1. *The pupils' knowledge*

For all the achievement variables used within the main investigation, for the results of the diagnostic tests and the prognostic tests within the material study and for the majority of the terminal tests in the goal testing study the same fact applies that the pupils who have chosen the special course do better than the pupils who have chosen the general course. This must, however, be seen in relation to the connection between ability (measured primarily in marks from grade 6 and certain aptitude tests in mathematics) and choice of course. This connection, which is considerable, states that the pupils in the higher group in the above-named respects predominantly choose the special course, while pupils in the lower group predominantly choose the general course. Since it has not been possible to compare the knowledge of the IMU pupils with that of pupils using other study material because of the differences

in the course content, it is not possible either to state whether the difference between general course and special course pupils becomes greater or smaller with a self-instructional study material.

5.4.2. *The pupils' attitude towards working with IMU*

The attitude of the pupils towards school in general and mathematics in particular, towards working with IMU with regard to method, material, course content and their more general attitude to IMU as it was studied in the main investigation, their attitude to the material as it was studied in the material study, show very few differences between pupils who had chosen the general or special course. In the main investigation there are only two out of a possible one hundred and twenty-three (123). Examination of the effect size index that has been used (ω^2) shows that for the variables in the main investigation about 70 per cent of the ω^2 values measured are less than or equivalent to 0.01 (1 per cent), while only eight of the 123 have ω^2 values of 0.03 or above, of which only two were thus on 0.05 or above.

For the same reason as that given above in the question of the pupils' knowledge, there is no possibility of deciding whether the lack of differences between the attitudes of general and special course pupils is a result of IMU and the way in which it has been used, or something that would have occurred with any self-instructional study material.

5.4.3. *Teachers' views on the organizational discontinuation of alternative courses*

The problems connected with alternative courses have only been touched upon by teachers in two part-studies and in both cases it was in connection with prognostic tests and the setting of marks. In the summary of the work done by the project consultants, the question is taken up by teachers in connection with the prognostic tests—they want alternative prognostic tests as long as the alternative courses still exist (the prognostic tests are the same for both general and special courses in IMU). In the interview material in Part I of the job-analytical study there are situations that describe the difficulties in setting marks that arise from the continued existence of the alternative course, despite the fact that IMU is arranged as a uniform mathematics system. Otherwise no opinions on the alternative courses have been put forward, either in direct questions from the project or in spontaneous comments by the teachers. On the other hand, there are in several of the part-studies points of view concerning the weak pupils and the difficulties associated with them. As has already been pointed out, the connection between choice of course and achievements is relatively high, but since the teachers themselves have not associated the

two factors in their comments the problems of the weak pupils do not appear to be a consequence of difficulties resulting from the organizational discontinuation of alternative courses.

Thus there are no data in the investigation of effects that speak against giving up alternative courses when using IMU material. Some additions to the material with regard to the prognostic tests are desirable, however, if the alternative courses are to remain.

6. The Material

One of the part-studies of the investigation of effects has comprised testing the material. To this can be added sections from other part-studies, which have dealt in greater or lesser detail with the opinions of both teachers and pupils about the material as a whole and in part. As was pointed out in chapter 2, the material must be considered together with both the goal descriptions and the terminal tests. The results from the terminal tests cannot be unequivocally attributed to the material, however, as the pupils' knowledge and skills are not simply a function of the material but also of method and organization and also naturally to a great extent of the pupils' own qualities. The testing has provided information about weak points in the material where revision is desirable, even if this information is not always accompanied by ideas as to how these revisions should be made. There are, for example, no analyses of the mistakes made in the individual tasks in the booklets. The original plan for the material study included examination of the pupils' booklets. Changes had to be made in that respect rather soon. There were several reasons for this but the most important was that the answers to the tasks were included in the key which the pupils had. When a few tasks, the answers to which were "fortunately" wrong in the key, were checked, it proved that the number of pupils who copied the answers from the key was far too great for analyses of the booklets to give valid results. It would be very difficult to check the way in which the pupils use the key since such checking would have to be done by the teachers. It was thought to be unrealistic to add this extra task to the teachers' workload.

The other data from the material study (the results of diagnostic and prognostic tests), information that was given to the project consultants and opinions on the material in the main investigation in particular can all contribute ideas, however, as to *how* a revision should be made.

As far as the goal descriptions and terminal tests are concerned, they can well be said to be unique documents—no other Swedish study material or material/methods system is based on so detailed analysis of the curriculum and there are hardly any other goal analyses and/or terminal tests that cover a complete school level (three years of study).

6.1 General opinion of the material

In the main investigation's pupil study the attitude towards the material has formed one variable domain. The results there show that the pupils are relatively positive towards the material as a whole; they are satisfied with the number of diagnostic tests and prognostic tests, they find the text relatively easy to understand, but find the booklets neither particularly enjoyable nor particularly boring. The attitude to the material in these respects does not differ for the different groups of pupils.

The attitude of the teachers towards the material is also largely positive, as can be seen from their answers to the question "What is your attitude towards version 3 of the IMU material?". The question was put in the spring of grade 7 and the spring of grade 8 and was drawn up in the same way as the question about the method (cf. p. 39 ff.).

Table 11. The teachers' attitude towards version 3 of the IMU material.

Alternatives	Spring grade 7		Spring grade 8	
	no.	%	no.	%
very positive (1)	16	6.1	5	1.9
2	70	26.7	66	25.2
3	102	38.9	88	33.6
4	52	19.8	61	23.3
5	13	5.0	30	11.5
6	8	3.1	11	4.2
very negative (7)	1	0.4	1	0.4
Total	262		262	
Mean	3.02		3.31	
Standard deviation	1.10		1.17	

They consider, however, that the number of prognostic tests is too small (cf. also section 5.4.3.). The comments made by the teachers on the actual material are mainly positive.

The results of the material study show that on an average the pupils find the booklets neither difficult nor easy, though with a tendency towards easy. There are individual cases of booklets that are felt to be difficult, however. Their opinions as to how enjoyable or boring the booklets are to work with lie on an average around neither boring nor enjoyable, often with a tendency towards boring. There are individual cases, however, in which the booklets are felt to be enjoyable, this applies particularly to the A components.

The way in which the material functioned for pupils of varying ability can be summed up most simply by saying that for good and average pupils it

functioned satisfactorily, but that it did not function particularly well for the weaker pupils. Even level 1 of the various B and C components has often been too difficult for this latter group. The import of "satisfactory" has been based on the results of the diagnostic test—the average percentage of correct answers should be at least 80 to be considered satisfactory. This arbitrary level can of course always be debated. It can well be said, however, that the results of the diagnostic tests should have a high average level, since these tests are not to differentiate between the groups of pupils, but to show that the pupils have grasped what they went through in the last booklet they studied.

The prognostic tests can be said to differentiate well between the groups of pupils. The three versions to each module have been found to be parallel.

Thus the total picture of the material seems positive, but there are nevertheless sections which have been criticized. Results of both the material study and the goal testing study suggest need for revision.

6.2 Sections requiring revision

Four content areas in the course are unanimously pointed out in several studies as requiring revision. They are the slide-rule, approximate calculation, algebra and solution of equations.

The slide-rule is dealt with in modules 3 and 4. The pupils find this item both enjoyable and easy in module 3, but change their opinion when they meet it again in module 4, when the most common answer is that it is boring. The item has also been felt to be less easy then. The project consultants state in their summaries that the section on the slide-rule has according to the teachers become too compact and that it is an item that should be spread out over more teacher-led teaching. The terminal tests show that the pupils have a fairly good grasp of multiplication and division with the side-rule but manage squaring and the extraction of square roots less well. The terminal tests also show that the pupils' ability to use the slide-rule is greater than their ability to say what the different parts of the rule are called—a result that there is perhaps no great reason to deplore. It should be considerably more important that the pupils can use the slide-rule than that they know what its parts are called, at least when they have reached the point that they can use it independently.

Approximate calculation, which occupies a dominant position in the curriculum of 1969, cannot be said to have functioned satisfactorily. The item has been placed relatively early in the material and has there been given an intensive treatment, after which it does not recur to any noticeable extent. Considering the central position the item has been given, the results of the

terminal tests are bad. The project consultants report criticism from the teachers of this item. They have said that approximate calculation is well-suited to teacher-led explanation, preferably more closely linked to practical exercises and examples. The material study does not have any results indicating that this particular section functions much worse than others, but the pupils do not find it particularly stimulating to work with, the majority finding it dull though not difficult.

The algebra section that comes mainly in the latter part of the material, in module 9, has according to the material study, been felt by the pupils to be both difficult and boring. It has not functioned particularly well, either. The goal testing results show on an average low frequencies of correct answers, among the lowest for the 17 different areas of the material. In this context it should be noted, however, that algebra has not occupied a prominent position in the study material and that the section comes late in the material, so that several pupils had not come to it when they did the terminal tests.

Finally the section on equations has been criticized by the teachers. The project consultants report that the pupils have had difficulty in managing the equation section, largely because the authors have carried the mathematical stringency too far. They also point out that the equation section is well-suited to oral explanation. The results of the material study show that the pupils find the equation section, especially in module 8, both difficult and boring. The goal testing results show that the frequencies of correct answers for the section are rather low and for the solution of equations very low.

The prognostic tests have been criticised rather severely by the teachers. Apart from the fact that they think there are too few of them, they are of the opinion that since for the purpose of setting marks the pupils are still divided into general and special courses, there should be special prognostic tests for the two courses also. The material study does not, however, support the opinion of the teachers that the high-achievement pupils do all the tasks while the low-achievers do none or very few. The versions of the prognostic tests have also been criticised for being too similar—they make it possible for the pupils to get tips from classmates who have done a test earlier. It is, however, necessary that the prognostic tests should be parallel. That this is the case has been proved in analyses in the material study.

As has been shown above, the investigation of effects has worked with version 3, while the version now being used is version 5. Following certain results from the material study and from the work of the project consultants in the field, the material was revised during the school year 1969/70 and version 5 came into use during the school year 1970/71. The most radical measure was the construction of another level, a level that lies below level 1 of the third version. In addition changes were made in the structure of the material, in that the D component was excluded and a G component con-

structed instead. The main purpose of this was to bring about an increase in the proportion of group teaching but also increased control of which content areas are suitable for group teaching. Both these measures were received with satisfaction in the schools.

6.3 The terminal tests

What has caused most difficulty in the evaluation of the results of the terminal tests has perhaps been the impossibility of relating the results from the investigation of effects to non-IMU-pupils, because of the differences in the course content. As there is no clearly defined level of requirements in the goal descriptions it is rather difficult to evaluate the results *within IMU* and the fact that when the tests were given almost only IMU pupils were working with the new course content makes it impossible to evaluate the results vis-à-vis *other upper level pupils*. As has been mentioned earlier, this will become possible during the spring of 1973, when all pupils in grade 9 will be working according to the 1969 curriculum. Even then complications will arise, however, if one wants to compare the results from tests done in the spring of 1971 with the results for the spring of 1973, since on the former occasion the IMU pupils belonged to the last batch of upper level pupils who could choose not to study mathematics in grade 9.

The question put on p. 32.—What level of knowledge and proficiency have the pupils reached at the end of grade 9, measured in the terminal tests that have been constructed on the basis of the goal descriptions and material?—can only be answered in absolute terms. It is possible to give the results as such, expressed, for example, in percentages of correct answers for the different areas, for items within these areas and for individual tasks and tests within items and within areas of the material. This provides percentages of correct answers for almost 700 tasks. With this background, however, it is difficult to make statements on the extent to which the IMU pupils have attained a satisfactory level of knowledge and skills after working with IMU for three years.

The original report, which is indispensable for anyone who wishes to penetrate in depth the execution and results of the terminal tests, discusses the results from several different aspects. Two of these are the realism and relevance of the goals. The former is considered in terms of both economic resources and the learning potential of the pupils under given conditions. The question of economic resources includes the effects of the organizational experiments that have been part of the investigation of effects with all its sources of variation, together with the organizational discontinuation of streaming.

The learning potential of the pupils covers a discussion of the possibility of predicting the study results both from data about the pupils themselves and from general teacher experience. It should in any case be very difficult, if not impossible, for those constructing IMU's goal descriptions to assess how realistic the goals established were. Goal realism is something that must be judged at a later stage. This comparison can hardly be completely meaningful un il the opportunities for comparison described above exist.

Goal relevance is discussed in the original report from four main angles: the school's obligation to prepare the pupils for their future careers, the social requirements irrespective of future careers, continued higher education and finally the transfer potential of different goals, that is to say the extent to which a goal is of more general use.

Section I.2. of the Appendix presents in an extremely condensed form the main results of the goal testing study. These results must also be assessed, however, in the context of the tests that have been constructed. In an omnibus report it is not possible to take up each individual test and it is hardly meaningful to discuss and analyse the individual results either. The pattern that has emerged in both the main investigation and the material study, namely that the pupils with the most ability at the start of the experiment also reach better results in the measurements of knowledge and skills, also appears in the results of the goal testing study. The lack of differences in knowledge and skills that was found for the groups of pupils in different organizational models in the main investigation, reappears in the goal testing study.

The fact that both the goal descriptions and the terminal tests must be unique documents does not mean that they are in any way final documents. One important result from the work with goal descriptions and terminal tests should be, however, that they can provide a basis for continued work with analyses of the goals for mathematics teaching in the upper level of the comprehensive school.

The data from the investigation of effects have shown that the material has on the whole been given a positive reception by both pupils and teachers. Certain sections of it have been criticised, however, and in some cases this has already been remedied in the revision that has been carried out. To this must, however, be added the fact that the pupils entering grade 7 in the autumn of 1973 will be the first ones who have followed the 1969 curriculum in the middle level. Thus it will be necessary to make adjustments, since the initial knowledge of the pupils will not be the same as in previous years.

7. The Organization

Much of the experience gained during the preliminary experiments (prior to the start of the project in 1964 and during its first years) indicated that it should be possible to change the organizational forms of the teaching. By change is meant that the traditional division into one class—one teacher could be replaced by other models. During the experiments that were carried out with version 2 (1967—70), however, no particular emphasis was laid on the forms of organization and the analyses that were made involved only the rough division large class—one class. In the investigation of effects, however, considerable emphasis has been placed on investigating the effects of different organizational models for both teachers and pupils. When the investigation of effects was planned, a model was drawn up that would allow multiple factorial analysis of the three main factors of the organizational forms: the size of the pupil group, the composition of the teacher team and the disposition of rooms by the teaching unit. It was considered essential that the interaction between these factors be investigated. For various reasons this model could not be used, however: a larger number of schools than those that had been granted permission for experimental work would have been required and they would have had to agree to change neither the organizational model they had started with (preferably the schools should have been allocated a particular organizational model) nor the composition of the teacher teams (no staff changes). Therefore the three main factors have had to be largely analysed separately. For some of the teacher data it has been possible to analyse at least two of the factors at the same time.

The method manual takes up certain basic suggestions for organizational models, centered around three-class or two-class with varying teacher density and with or without the help of a teacher assistant. At the same time as the school received permission to take part in experimental work, advice and directives were sent out by the project about which alternatives were possible, calculated mainly on the basis of the number of parallel classes. The schools have on the whole been free within the limits of the resources available to choose which organizational model they wish and to change model during the

experimental period. As a result local adjustments have been made in the original models and local arrangements have been carried out with varying teacher density, varying group size etc. The latter point should be kept in mind when going through the organizational picture during the experimental period and in interpreting the results that have been obtained.

Each term the project has gathered in information about the organizational model(s) being used at the various schools and on the basis of this information the schools have been placed in different types of teaching units. This information has also been used in investigating which changes have taken place with regard to the organizational model.

7.1 Organizational models during the experimental period

Combinations of the size of the pupil groups, the composition of the teacher teams and the disposition of rooms have resulted in 74 possible organizational models, as can be seen in Box 5.

The figures in the cells refer to the numbers of the respective models. Of these 74 only 36 have been used, however. The occurrence of a model and in which term are shown in Table 12.

In the majority of both three-classes and two-classes a teacher assistant is included in the teacher team, while the majority of one-classes have no assistant. The changes that have been made during the experimental period are partly shown in the table: the number of large classes has diminished and the number of one-classes increased. Changes have also been made *within* the teaching units. The teacher density has increased in some three-classes from two teachers and assistant to 2.5 teachers and assistant (applies to 15 units) and the number of three-classes without an assistant has decreased. The changes are less for the two-classes. In some cases the teacher density has increased from 1.5 teachers with assistant to 2 teachers with assistant (applies to 4 units). The increase in the number of one-classes has come about by former three-classes and two-classes being split. In some cases former three-classes have been made into both two- and one-classes, former two- and one-classes have formed three-classes etc. As far as the disposition of rooms is concerned, both three- and two-classes have predominantly been taught in several classrooms (applies to about 2/3 of the three-classes and about 3/4 of the two-classes). The most common large-class models have been:

	three-classes	two-classes
size of pupil group	80—90	50—60
composition of teacher team	2T + A or 2.5T + A	1.5T + A
disposition of rooms	several rooms	two rooms

Box 5. Combinations of the number of classes in the unit (C), number of pupils in the unit (P), number of rooms in which the pupil unit works (R) and composition of teacher team (T = teacher, A = assistant).

		C = 3				C = 4	
		2T + 1A	2.5T + 1A	3T	3T + 1A	3T + 1A	2.5T + 1A
P 60—69	R1	1	8	15	22	29	36
	R > 1	2	9	16	23	30	37
P 70—79	R1	3	10	17	24	31	38
	R > 1	4	11	18	25	32	39
P 80—90	R1	5	12	19	26	33	40
	R > 1	6	13	20	27	34	41
P > 90	R > 1	7	14	21	28	35	42

		C = 2				
		1.5T + 1A	2T	2T + 1A	2T + 0.5A	1T + 1A
P 30—39	R1	43	49	55	61	67
	R2	44	50	56	62	68
P 40—49	R1	45	51	57	63	69
	R2	46	52	58	64	70
P 50—60	R1	47	53	59	65	71
	R2	48	54	60	66	72

	C = 1	
	1T	1T + 1A
P ≤ 30	73	74

Table 12. The occurrence of models and the term.

Model no.	Autumn '68 no.	Spring '69 no.	Autumn '69 no.	Spring '70 no.
1	2	2	2	2
2	3	3	3	3
3	4	4	3	1
4	7	7	5	5
5	15	16	9	8
6	22	21	16	15
10	2	2	2	3
11	1	1	2	2
12	0	0	8	9
13	11	11	15	12
15	0	0	0	0
16	1	1	0	0
18	1	1	1	1
19	1	1	0	0
20	3	2	1	1
21	1	1	1	1
26	0	0	1	1
27	2	2	3	5
31	0	0	0	1
35	3	3	4	4
45	3	3	2	1
46	6	6	5	3
47	2	2	3	4
48	17	17	16	15
53	0	0	1	1
54	4	1	1	1
55	0	0	0	1
57	0	0	1	2
58	0	0	0	2
59	3	3	3	3
60	3	3	4	5
66	3	3	1	1
67	2	2	2	1
68	1	1	1	1
73	65	72	73	80
74	14	16	20	17
Number of models	28	28	30	33
Number of units	202	207	209	212
Number of classes	407	407	405	406
% three-class	39	38	36	35
% two-class	22	20	19	19
% one-class	39	42	45	46

Increase in the number of teaching hours has occurred to varying extents. The picture we have of this is less clear, however, since there has been no systematic collection of information about that aspect in the main investigation. There is a certain amount of information in Part II of the job-analytical study, however. There it has emerged in the cases where this increase has occurred that it is most usual for the clinic teacher or remedial teacher to come to the teaching unit in question, less usual for the pupils to leave the teaching unit in order to get extra help.

As has already been pointed out, the three factors have in the main been analysed separately. Any elucidation of the outcome within the investigation of effects must therefore also mainly be done separately, even if for above all the teacher data there is some possibility of linking two factors.

7.2 Class size

Division according to class size means division into three-class, two-class and one-class. It has been utilized in analyses of both the pupil and teacher/assistant data in the main investigation, in Part II of the job analysis study, in the observation study and in the goal testing study. In the latter case three-classes and two-classes have been combined into large-classes in the data processing.

7.2.1. *Effects on the pupils*

In division according to class size no difference appears between the three pupil groups for any variable in the main investigation. All ω^2 values calculated are below 0.03 and only eight of the 134 values are above 0.01. Thus the main investigation's pupil study provides no information as to whether any one of the class sizes is to be preferred.

In the goal testing study differences occur on some tests/tasks between large-class and one-class pupils. These differences do not point consistently in one direction however; in some tests/tasks the large-class pupils are best, on others the one-class pupils.

7.2.2. *Effects on teacher teams*

Division according to class size in the main investigation's teacher study produces in many cases differences between the three groups of teachers. To a very great extent, however, they involve the distribution of working time between different tasks during and outside lessons. The differences that also exist with regard to the teachers' attitude towards IMU mainly concern the effect the work has on their own situation. When interpreting the differences

between the teacher groups according to class size. it must be remembered that the three-class and two-class teachers most often work with the help of an assistant, the one-class teachers without such help.

The differences between the teacher groups are consistently that the one-class teachers must spend more time on administration, while teachers in large classes devote more time to conferences and tasks connected with them. During lessons more of the one-class teacher's time goes on administration, while the large-class teacher can spend more time on group teaching. If one adds up the amount of time required for administrative tasks outside lessons, it varies between 24 and 34 minutes per week for large-class teachers and between 87 and 102 minutes for one-class teacher (calculated from the various measurement occasions). The corresponding amount of time for administrative tasks during lessons varies between 5 and 15 per cent of the lesson time for large-class teachers and between 15 and 30 per cent for one-class teachers. Conferences and the work they involve take an average of 50 minutes per week of the large-class teachers' time, and about 10 minutes of the one-class teacher's. Group teaching takes on an average about 10 per cent of the three-class teacher's time, about 8 per cent of the two-class teacher's and about 5 per cent of the one-class teacher's. (The figures given for conferences and group teaching refer to the last two measuring occasions.)

7.3 Disposition of rooms

Categorization according to disposition of rooms means division into "one room"—"several rooms". Only large-classes have been included in the analyses that have been carried out. As far as "several rooms" is concerned, it is only as an exception that the information from the schools has included the actual number of rooms involved. For this reason the division can only be done roughly. Data from the main investigation's pupil study and teacher/assistant study have been analysed in this respect. The reports from the project consultants also provide information about the arrangement of the rooms.

7.3.1. *Effects on the pupils*

With classification according to disposition of rooms: "one room"—"several rooms", no differences between the groups of pupils occur for any variable in the main investigation's pupil study. Of the 134 ω^2 values calculated, only 11 are above the value 0.01, the highest value being 0.02. Thus the main investigation's pupil study provides no information as to whether any particular disposition of rooms for large-classes is preferable to others.

7.3.2. *Effects on teacher teams*

In the main investigation's teacher data there are only a few differences between the teacher groups when classified according to "large class in one room"—"large class in several rooms". The only consistent difference is the relatively self-evident one of the time needed by the teachers for going from one room to another being longer if the large class is working in several rooms. In addition group teaching occurs more often in grade 8 in large-classes using one room, class teaching occurs more often in large-classes using several rooms (this is obviously a mixture of class and large-class). There are a few differences in the attitudes of the teachers towards the work with IMU, but they are such that the answers reflect various degrees of "neither—nor", that is to say, a neutral attitude. Thus the main investigation's data provide no information as to whether one or several rooms is best.

The report from the project consultants also mentions the question of rooms. It emerges that when the teaching units work in one room, it is usually either in a dining room or an assembly hall. In the first case the main problem is sound insulation, in the second it is the fact that the desks and other fittings cannot be rearranged. It seems as if the alternative with several rooms has functioned best in the cases when it has been possible to work in adjoining classrooms and in addition either open up doors or even whole walls between them. When it has not been possible to take such measures, the teacher density has sometimes been increased to one teacher/class(room) in the large-classes, even if this has been at the expense of losing the assistant. (This particular form of "large-class" has been paid special attention; the project team has been aware that this kind of large-class arrangement is in many ways similar to the one-class model!)

The two factors dealt with so far in the organizational pattern reveal no unequivocal advantages or disadvantages. The categories that could be used have been rather broad, however, and it is perhaps not particularly suprising that so few differences appear. As has been pointed out, it has been possible to analyse the organizational pattern of the large-classes in more detail, in particular with regard to the teacher density. Another vital factor in the organizational pattern is the role of the teacher assistant.

7.4 Teacher density

The survey on p. 58 shows that the most common teacher constellation in three-classes has been either 2 teachers and an assistant or 2.5 teachers and an assistant, and in the two-classes 1.5 teachers and an assistant. For all the

large class units, the division of the units over models with and without an assistant in combination with the teacher density is the following.

Table 13. Teacher assistants and teacher density in large-classes. Number of units.

	Autumn '68	Spring '69	Autumn '69	Spring '70
Three-class				
< 1 T/class without assistant	0	0	0	0
< 1 T/class with assistant	70	70	69	65
1 T/class without assistant	7	6	3	3
1 T/class with assistant	2	2	4	6
Two-class				
< 1 T/class without assistant	0	0	0	0
< 1 T/class with assistant	31	31	29	25
1 T/class without assistant	4	1	2	2
1 T/class with assistant	9	9	9	14

Reduced teacher density (less than 1 teacher/class) does not occur unless an assistant is included in the teacher team. The majority of the large-classes have worked with reduced teacher density and the help of teacher assistants.

A survey of the development of the teacher density during the four terms studied shows the following.

Table 14. The development of the teacher density.

		Percentage with 1 teacher/class	Percentage with less than 1 teacher/class
Autumn '68	only large-class	18	82
	all units	50	50
Spring '69	only large-class	15	85
	all units	51	49
Autumn '69	only large-class	16	84
	all units	53	47
Spring '70	only large-class	22	78
	all units	58	42

There has been some increase in the teacher density. Taking the large-classes alone, however, this increase has been moderate with regard to the increase up to 1 teacher/class. When interpreting the values, it should be remembered that the increase from 2 teachers and assistant in the three-class to 2.5 teachers and assistant are not included above (this increase has occurred

in 15 out of 38 units). Taken over all units, there has been an increase in the teacher density up to 1 teacher/class, brought about mainly by going over from large-class to one-class. At the start of the experiment in the autumn of 1968, 50 per cent of the units were working with complete teacher density, at the end of grade 8 this percentage had risen to 58 per cent. The corresponding values from the large-classes alone were 18 and 22 per cent respectively. When the experiment began, 61 per cent of all units were large-classes and 82 per cent of them were working with reduced teacher density. The corresponding values at the end of grade 8 were 54 per cent large-classes in which 78 per cent worked with reduced teacher density.

The picture given above must be supplemented on two points. Firstly, the teaching was given a certain increase in the number of teaching hours, mainly by letting the clinic/special teacher visit the teaching unit for part of the week's lessons, but also by sending pupils to the clinic or special class. Secondly, it should be noted that by doing away with the need to organize division into alternative courses, the number of teachers required was automatically reduced, in addition to what happened in the majority of the large-classes.

7.4.1. *Effects on the pupils*

The main investigation's pupil study made it possible to analyse the teacher density combined with the disposition of rooms for the large-classes: large-class in one room, large-class in several rooms but with less than 1 teacher/class and large-class in several rooms and with 1 teacher/class. Thus this last group of pupils belong to the large-class organizational models that would be able to function as one-classes (cf. above p. 62). One-class pupils are not included in the analyses.

There are no differences between the three groups of large-class pupils for any of the 134 variables analysed. Two ω^2 values lie around 0.04, the others that are above 0.00 lie within the interval 0.01—0.03. Scrutiny of the group mean values for the two variables reveals that the group that deviates is the one with large-class pupils working in several rooms with less than 1 teacher/class. These pupils feel that the discipline in the class during mathematics lessons compared to other lessons is "somewhat worse", while the value for the other pupils states "neither better nor worse".

7.4.2. *Effects on the teachers*

The problems connected with the teacher density have been examined in certain designs in both the main investigation and the job analysis study. Sometimes the teacher density has been linked to the disposition of the rooms. Among the results of the main investigation is the fact that the higher the

teacher density is in the large-classes, the more time is spent on handling material both during and outside lessons, and the lower it is the more time is devoted to conferences. The former result can to some extent be connected with the amount of help available from assistants, since a teacher density of 1 teacher/class during the two first terms often meant a teacher team without an assistant. This applies only to the three-classes.

There are also other effects of the teacher density in combination with room disposition. They suggest that teachers working in a team of less than 1 teacher/class and in one room feel that they have fewer chances of making direct contact with the pupils and of checking the pupils' work. Teachers in a team of 1 teacher/class working in one room react negatively to the IMU system and the work in it. They also feel that the teaching is more monotonous for them and less qualified than conventional teaching. All the differences given above occur only in the measurement made in the spring of grade 7. The effects of the reduced teacher density appear reasonable, as do perhaps the effects with full teacher strength where the work is done in one room. In the latter case, it is possible that the teachers feel more exposed to the observation of their colleagues and perhaps also feel that they have fewer opportunities for taking any initiative during the lessons. Taken as a whole, however, it must be said that the teacher density produced relatively few differences in the main investigation. (There is one group of teachers who often show deviations and then always in a negative direction. They are three-class teachers who work in one room with full teacher density and with no assistant. This "group" consists of a single teacher team at one school, however. How far this negative attitude is a result of the organizational model as such or whether these particular three teachers at this particular school and the conditions there cause the negative attitude cannot be learnt from the data.)

The job analysis study also deals with the teacher density. The job descriptions contain situations that show that low teacher density causes difficulties in arranging group teaching. Difficulties also arise for the teacher who is left in the teaching unit in finding time to help all the other pupils in the large-class. Disciplinary problems are also taken up in this context. In Part II of the job analysis study the composition of the teacher team has been included as a design variable. It takes up the four most common organizational models: 1 teacher without assistant (one-class), 1.5 teachers with assistant (two-class), and 2 or alternately 2.5 teachers with assistant (three-class). So here there is full teacher density only in the one-class model. Rather many of the differences that exist between the groups arise from the one-class teacher deviating from the others and in the great majority of cases doing so by stating a lower degree of cooperation. The point that is of the greatest interest here is seeing whether three-class teachers who work in teacher teams with 2 and 2.5 teachers respectively differ in their assessments. The teachers in the larger

teacher teams are more often faced with certain situations, primarily in the categories "registration/office routine", "training of new pupils" and "measuring achievements", but less often with other situations in the categories "teacher team conferences" and "giving information". These differences cannot be explained by assistant participation, as assistants are to be found in both types. The increase in "registration/office routines" confirms what emerged in the main investigation—increased teacher density led to increased contact with material in various ways ("administration of material"). The explanation for this can possibly be that in teams with low teacher density the teachers must leave all such tasks to the assistant, while the teachers in the larger teams can relieve the pressure on the assistant. It can also be so that in the larger teacher teams the increased costs for teaching posts are compensated with a reduction in the number of assistant posts. A third explanation can be that the teachers occasionally want to have a certain amount of contact with the material if this at the same time leads to contact with the pupils. In the cases where differences have been found in registration, it has been registration of points reached by pupils in the material and in results of diagnostic tests and prognostic tests and registration of the pupils' choice of level.

There are also certain differences in the situations with which the two teacher team constellations are faced. A fairly common result is that there is more cooperation between the members of the team in the larger teacher teams—a fact that is hardly surprising. In the cases when there are differences between the groups in the degree of stimulation the various work situations give them, the tendency is most often that the larger teacher teams feel a greater degree of stimulation. Moreover, in practically all cases of differences between the groups in the degree of difficulty in the various work situations, the larger teacher teams state a greater degree of difficulty Sometimes this is linked with "more cooperation"—"more stimulus", in others differences in the difficulty aspect are the only ones to emerge. The latter applies to work situations connected with catching the interest of the pupils and motivating them, devoting time to pupils with contact problems, but also those in connection with discussions at teacher team conferences about how to behave in front of the pupils. One would think that the first two situations should be easier to deal with the more teachers there were (the number of pupils in both models is 80—90). The third difference can perhaps be associated with what was said earlier about high teacher density and working in one room (disposition of rooms is not included, however, in the job analysis study), that is to say, that the more people there are in a team, the more one can feel oneself observed by colleagues with subsequent difficulty in discussing problems that arise. But even if there are certain differences resulting from the teacher density in the three-classes, they are relatively few in number.

The report from the project consultants also takes up the question of teacher

density. It discusses primarily the three-class organization with two teachers and an assistant. Several teachers working in such teams have been negative. The most common countermeasure has been to increase the teacher team with a part-time teacher (teacher working for 2 of the 4 lessons a week) as has already been shown above. This increase has obviously made the work in the large-classes easier. Even in the cases when the change has been made to a teacher density of 1 teacher/class, the large-class organization has been retained.

The actual number of pupils per teacher was in the spring of 1970 about 33 for large-class teachers and 27—28 for one-class teachers (cf. Appendix II.1.16.). Assistant participation in a large-class led to no increase in the number of pupils, while having an assistant in a one-class gave an increase of one or two pupils. The desired number of pupils per teacher was connected with whether there was an assistant or not: the large-class teachers who worked with the help of an assistant had the actual number of pupils per teacher they desired, without the help of an assistant the large-class teachers wished to have about 10 pupils less to instruct. For one-class teachers the desired maximum number of pupils was about 31 pupils with the help of an assistant, reduced to about 22 if no assistant was available. The same tendency with regard to the desired number of pupils is to be found in the job analysis study. There the importance of the assistant also emerges clearly—even those who prefer the one-class model want to work with the help of an assistant. What has been said above has already shown how important the role of the assistant is in IMU teaching. This importance will be further illustrated with data from the different studies.

7.4.3. *The teacher assistants*

The part-study carried out within the main investigation that deals with the group of teacher assistants has produced results that confirm what has emerged either directly or indirectly in the other studies. The assistants carry out a series of tasks, primarily concerned with administration, but are also involved to a considerable extent with the teaching. The method manual contains relatively detailed descriptions of the main tasks that the authors have thought that the assistants should have, and in this the handling of material occupies a dominant position.

The main investigation's pupil study shows no differences between groups of pupils that result from whether an assistant has participated or not. Of the 134 variables analysed, 18 have ω^2 values above 0.009. Fifteen of these lie within the interval 0.01—0.019, however. Therefore it is mainly in analyses of data from the teachers and in the analyses of the assistants themselves in the job analysis study that their role is shown.

One consistent result in both the main investigation and in the job analysis study is that teachers who have the help of an assistant devote considerably less time to various administrative duties in connection with IMU teaching. Since it is primarily one-class teachers who work without an assistant, their tasks will differ from those of large-class teachers on essential points. Scrutiny of the tasks the assistants themselves say that they have confirms this. But the assistants also have some duties that are more directly connected with the teaching. They contribute to a large degree, for example, in the pupils' choice of level, they correct the diagnostic tests and go through them with the pupils. The assistants often correct the prognostic tests, they put together material for the teacher team conferences and they help in selecting pupils for group teaching. Another consistent pattern to be found in the job analysis study is the more positive attitude of the assistants, taken as a whole, towards various tasks. Noticeably often they find the work situations more stimulating than the other members of the teacher team do and easier to deal with, they state a higher degree of cooperation and they often wish that they could devote more time to the various situations. The fact that this positive attitude applies to the tasks concerning registration and office routine is perhaps surprising, but all the more pleasing. The pattern often also emerges, however, in the situations that lie outside the routine work and that can be considered more as teacher tasks. On the whole the assistants seem to be more positive to the work with IMU than the teachers. A factor that is certainly not without significance in this context is that the assistants form a new "professional" group. Since they usually have secretarial training, the contact with teaching and teachers/pupils gives them new, different tasks in their work—it could be said that the personal contacts introduce a new dimension into the administrative routines. Further factors that can be of great importance are that accepting the post of assistant hardly necessitates any process of adaptation for them since, unlike the teachers, they are not tied to earlier habits in teaching situations.

The project consultants report that the assistants in general are well-qualified for their tasks (the administrative ones). Obviously they are in many ways also qualified for tasks outside the administrative framework. Considering all this, it is hardly surprising that the assistants have often expressed their disappointment over the conditions pertaining to their employment, especially the fact that their posts have not been salary-graded. This has led to there being considerable variations in salary between different schools/local authorities. Although the assistants have a positive reaction to the tasks and duties they have in their work, they request further training, particularly in mathematics, educational theory and psychology.

7.4.4. *Miscellaneous*

In both the main investigation's teacher study and in Part II of the job analysis study, the teacher group has been categorized according to certain external milieu characteristics. The size of the school locality in particular produces differences between the groups. In these cases it is often a question of deviation on the part of teachers working at schools in communities with more than 50,000 inhabitants, though not in the three cities (Stockholm, Gothenburg and Malmö, the three largest towns in Sweden, here called cities), and these deviations often have a tendency towards a less positive/more negative attitude. It is difficult to decide with any degree of certainty why the teachers in these localities should react in this way. A scrutiny of the variables in the main investigation where differences exist shows that they mostly concern the social contacts between teachers and pupils (cf. Appendix, pp. 109—110 and 112). Disciplinary problems are felt to be worse by the teachers here, a result that also showed up in part II of the job analysis study.

The results of the analyses of the organizational pattern do not provide any completely clear information as to whether any one organizational model should be preferable to the others. Comparing only the large-class and one-class, there appears to be some preference for the latter, judging by the changes made; the number of one-classes has increased at the expense of both three- and two-classes. The large-classes still form 54 per cent of the units after two years' experimentation, however (the proportion was 61 per cent at the start of the experimental period). There are no results in the pupil studies showing that any of the models gives better knowledge or a more positive attitude towards the work with IMU. This result is rather surprising. It can possibly depend upon the general adaptability of the pupils, that they can without any great difficulty get used to both new methods and new organization forms. It is therefore possible that the material they are to learn from and the way in which this material is presented is considerably more important for them, in other words that the design of the material is more decisive for the pupils.

Considering solely the large-classes, the reduction in teacher density by one teacher in the three-classes has created problems. The changes that have been made in such classes have usually consisted of increasing the teacher team with one part-time teacher. Within the two-classes, increasing the teacher density has occurred less often. There is one consistent pattern, however, and that is the importance of the assistants. Irrespective of the organizational model (large-class—one-class) the help of the assistants is assessed positively and it has emerged that the tasks undertaken by the assistants have to a considerable degree taken the form that was intended according to the method manual. The teachers' appreciation of the role played by the assistants is also

shown by the fact that they feel they can take on decidedly more pupils if they also have an assistant. Their estimation of their own work is also affected by whether they have an assistant or not—the teachers working without assistants have a less positive attitude towards their work situation with IMU than teachers who have the help of an assistant. As far as the actual arrangement of the rooms in the large-classes is concerned, there is a certain amount of evidence that working in one large room is less satisfactory than working in several adjoining classrooms. The fact that the "large rooms" (dining rooms, assembly halls) were not designed to be used for teaching is no doubt not unimportant.

Finally there is reason to emphasize that within the limits of their resources, the schools have been relatively free to choose which organizational model they wish and to make the changes in it that they deem necessary and desirable. In addition it is probable that the choice of organizational model reflects the initial attitudes and also that the composition of the teacher team, at least at the larger schools, has in no way come about by chance. It is therefore not surprising that there is an absence of clear results showing that one or a few models are the "best". In all probability the schools have themselves taken the measures they have found necessary and organized the teaching in such a way as to obtain the best possible adaptation to the local conditions. This freedom within the framework of the system must be seen as a necessary condition if the teaching is to function satisfactorily. The investigation of effects proves that to a relatively great extent this condition has existed.

8. The Changed Role of the Teacher

It should be clear from what has been said above that the group for which working with a self-instructional study material has caused the greatest changes is the teachers. Even though the investigation of effects does not include comparisons with conventional teaching, which in that case could have served as a point of reference, some new features in the teaching situation can be found. A survey made by Stukát (1970) produced a list of what the teachers are more, respectively less, involved in when they work with individualized teaching. The list should be seen as a series of predictions against which empirical results can be set. Data from the IMU project's studies of version 2 of the study material appear to confirm some of the predictions that were made (Jivén, 1968). Data from the investigation of effects have been analysed in considerably more detail, not least with regard to the role of the teacher, and an updating of the results of the project can therefore be needed.

According to the list, the teacher becomes *more* involved in:

individual contacts with the students
diagnostic and evaluative activities
prescriptions on learning activities and materials
planning and organization
preparation of instruction
cooperation with other personnel
counseling and guidance
supervision of students working independently
small group tutoring
stimulating and motivating students, giving positive feedback
higher-order cognitive, heuristic teaching

The teacher becomes *less* involved in:

contacts with the whole class
presenting fact information, drill-practice
routine managerial tasks
giving negative feedback
talking (total amount)
talking (in relation to student talking)

Stukát (p. 9 ff) has taken information from experimental work that has principally been arranged on the model experiment—control group. In IMU's investigation of effects there is no control group for the teacher studies. It will therefore be necessary to choose a somewhat different starting point in this case.

An examination of the role of the teacher in IMU must start from at least two premisses: intended and actual tasks for the teachers and the participation of assistants. The terms "more" and "less" are in some cases difficult to assess when it is a matter of changes from conventional teaching to individualized teaching, since there are no control groups. Some reasonable assumptions can be made, however.

One both intended and actual effect of the work with IMU is that the teacher becomes *more* involved in individual contact with the pupils. The use of assistants was intended to give the teachers more time for individual tutoring, but the actual results show that this happened only during the first term of the experimentation. Other tasks on the list connected with individual contact are diagnostic and evaluative activities, counseling and guidance, supervision of pupils working individually, stimulation and motivation of pupils and to some extent also teaching of a higher order. If one sees these latter tasks as representing individual tutoring of the pupils by the teachers, then both the intended and the actual effect of working with IMU should mean an increase for the teachers. The participation of the assistant comes in here, however, as a decisive factor in some cases—the diagnostic and evaluative tasks in particular are often transferred to the assistant, when there is one. In the individual case, this can mean that the teacher becomes less involved in the tasks than in conventional teaching, while if there is no assistant it should always apply that the teacher becomes more involved in the tasks.

Work with prescriptions on learning activities and material (which in the case of IMU usually refers primarily to study of the method manual and teacher instructions), planning and organization, and preparatory work connected with teaching probably also increase on an average compared to conventional teaching. This applies in particular if teacher team conferences are held, which occurs specially in the large-classes. The methodic instructions are perhaps more detailed for IMU than for other study materials, as the individual method of work makes quite different demands on the general control of the pupil's work. This applies irrespective of whether there is an assistant or not. Planning and organization of the teaching and preparatory work connected with the teaching occupy a relatively large proportion of all the teachers' working time outside lessons, although obviously in more structured situations for large-class teachers. The arrangement of this planning, the tasks it includes in detail, is connected with the participation of an assistant. It should not be all too risky to guess, however, that the teachers become more involved in the tasks mentioned with IMU than in conventional teaching.

The teaching of small groups was intended to increase, but the actual results hardly show any increase. It is, of course, difficult to ascertain to what extent the teaching of small groups occurs in conventional teaching, but it is clear that the intended proportion of small class teaching with IMU is considerably greater than the actual one.

The list included some other activities: the teacher becomes more involved in giving positive feedback and in teaching of a higher order. It is difficult to study such activities in the data here. And even though it seems reasonable that a teacher who wants to give positive feedback to individual students has a greater chance of doing so in individualized teaching, there is nothing to say that the two tendencies mentioned *must* be a result of individualization.

The fact that the teacher becomes *less* involved in contacts with the whole class is a both intended and actual effect of working with IMU. The actual effect is, however, greater than the teachers themselves would wish. The participation of an assistant is without importance here. The teachers are probably also less involved in presenting fact information and drill practice, if one by this means the formal treatment of mathematics. When group teaching has been used, it has been for going through sections that the pupils find hard. On the other hand, it is difficult to know what each individual case of tutoring has covered. But since the pupils work with such varying sections of the material, a guess can be made that both the intended and actual effect of individualized teaching has been a reduction of these activities compared to conventional teaching.

Routine tasks are assumed to decrease for the teachers in individualized teaching. It has been made quite clear that this is the case for the teachers working with IMU with the help of an assistant and equally clearly it is *not* so for the teachers working with IMU without the help of an assistant. On the other hand, one can query why this activity has been placed in the category *less* involved in: individualized teaching with IMU leads to increased administration at least—registering where in the material the pupils are working, and test results and going through the booklets of individual pupils must surely be far more necessary in IMU teaching than in conventional teaching, when the whole class is kept reasonably well together in the study material.

For the two remaining factors that the teacher is assumed to become less involved in, the same applies as was said above about giving positive feedback etc. There are no data in the investigation of effects that can prove or disprove whether the teacher becomes less involved in talking, either totally or in relation to the pupils. The teachers devote more than half of the time of the lessons to individual contact which the pupils. But in this contact a certain amount of the time must be spent on listening to questions from the pupils. It seems reasonable that the amount of teacher talking decreases with individualized teaching. At least the amount of talking should not increase.

From what has been said above, it should be clear that the changed role of the teacher is partly connected with how the teaching is organized and partly with whether an assistant participates in the teaching. Compared to conventional teaching, the teachers should in any case become more involved in individual contact with the pupils, get a partially different arrangement of the planning and organization of the teaching, possibly also an greater share in these tasks, and become more involved in instruction on method, at least until they have built up a routine in working with individualized teaching. The teachers become less involved in contacts with the whole class, probably also in the presenting fact information, definitely in drill practice. If an assistant is participating, they also get less involved in routine tasks, while if they do not have the help of an assistant they probably get more rather than less involved in such tasks.

The arguments given above only deal with the changed role of the teacher from the point of view of tasks and duties. The data provides little information about what this in its turn means for the teacher from the psychological, educational and social point of view. Nor do we know what it means in those respects for the teacher to leave his relatively isolated work as the single instructor for a class to become part of a teacher team that consists not only of other teachers but also in many cases of a representative of a new "professional" group—the assistant. The IMU project's investigation of effects has only been able to touch upon the effects of this change to a limited extent, but there is every reason to point out that this is a very important field for research. There is also reason to take such factors into consideration in teacher training—developments in the school must be followed up (and preferably preceded) by corresponding developments in the teacher training sector.

9. Final Comments

Above, as in the other reports from the investigation of effects, the main emphasis in the analysis and discussion has for obvious reasons been placed on questions within IMU. In the fourth point of the project's objectives (cf. p. 13), that takes up the purpose of the investigation of effects, it is said in parenthesis "... in connection with a comparison with conventional teaching". This parenthesis was put in as a safety measure, as those planning the project had realized at an early stage the difficulties that would arise in making these comparisons, because of the differences in the content of the courses being studied by the IMU pupils and the other pupils in the upper level of the comprehensive school. It could possibly be said now, when several years have passed since the investigation of effects was started, that these difficulties have proved to be even greater than was feared. But despite the fact that the investigation of effects has mainly worked with problems inside IMU, there is a great deal of information in the other part-studies that need not necessarily be linked with IMU. In concluding this final report, therefore, a few points will be taken up in connection with this information. There are, however, further questions within IMU that were dealt with in less detail in the discussion section. The Appendix does admittedly take up the main results of all the part-studies, but such summaries are of necessity compressed.

Some of these further questions will at least be mentioned. The debate that has arisen in recent years in Sweden on the subject of individualized teaching in general and IMU in particular has among other things concerned the social effects. It was feared that working with a self-instructional methods-material system such as IMU would greatly diminish the opportunities for cooperation between the pupils. The pupils work in isolation and the social objectives that are laid down in the curriculum cannot be fulfilled within the framework of the system. There is no doubt that the principle of individualized rate of work, for example, can lead to fewer opportunities for (or more accurately increased difficulties in) creating situations for cooperation. It is in any case a probable, if not necessary, result of the system. The data from the investigation of effects supports to a certain extent the assertion that the social objectives

have to give way for the individual ones, though without either the pupils or the teachers finding any noticeable disadvantages in this. The question is whether the school's objectives need be equally fulfilled in all subjects. Perhaps there are some subjects in which the social objectives can be satisfied more easily and better and others in which the individual objectives can best be served?

Another problem which is often taken up is the situation of the weak pupils, which it is feared will deteriorate in working with IMU. Particularly pupils with reading and writing problems were expected to have difficulties, since they were to obtain most of the information themselves by reading about it. The data of the investigation of effects have shown that version 3 of the IMU material was not sufficiently adapted for the weak pupils. The measure that was introduced in version 5, that is to say inserting another level below the first level of version 3, has probably remedied some of the difficulties. A more frequent use of group teaching is another measure that could help this group of pupils in their work. The weak pupils have not expressed a different attitude towards working with IMU, however—they demand more help from the teacher but otherwise their attitude towards IMU is the same as the other pupils'. One explanation of this can be that their situation has received more attention in the work with IMU through, for example, the recurrent knowledge checks that are built in (both those that the pupils correct themselves and the diagnostic tests proper) and through the contacts with the teachers. But on the other hand it can be an advantage for them to be able to put up their hands, get the teacher to come to them and ask questions without having the rest of the class listening. In that way their situation is less obvious. As far as pupils with reading and writing difficulties are concerned, it seems reasonable to assume that they have problems in acquiring knowledge. But even here the individual way of working can perhaps be positive, since their individual problems can be more easily identified than in conventional teaching. One result of the individual working method should be that the teacher devotes relatively more time to the weak pupils, both in relation to the other pupils in the class and compared to conventional teaching. With an unchanged teacher density, or as in the majority of the large-classes in IMU with reduced teacher density, this must mean that the amount of time the teachers spend on the other pupils is corresponding less.

Both these and many other factors in the investigation of effects deserve further consideration. Above all there is material in the investigation's data bank that can elucidate more problems, just as some problems can be given a more penetrating analysis.

This leads on to the results that must not necessarily be linked to IMU. There are some that deserve a closer study than it has been possible to give them within the framework of the investigation of effects. One such is the

effect of the external milieu on the teacher's and pupils' work. Especially in the teacher studies, results have emerged that suggest that the size of the school locality is of significance both for the tasks of the teachers and even more for their attitude towards working with IMU. The problem has been touched upon earlier (cf. section 7.4.4.) and it has also been said that without detailed studies of the schools and teachers from different sized communities it is very difficult to explain why teachers are so often more negative (less positive) in schools that are placed in large communities, excluding those in the three largest cities. Are these schools very big? Yes, there is a connection between the size of the school and its locality. But in the cities there are also large schools without the negative effects emerging so clearly. Something seems to characterize these schools and/or teachers in towns with 50.000 inhabitants or more, apart from those in the cities (Stockholm, Gothenburg, Malmö). An analysis and a description of these schools and teachers could perhaps shed some light on these effects that have been discovered but not explained in the studies. Such analyses would certainly be of interest even outside the immediate discussion of IMU.

The changed role of the teacher has been discussed. Attempts have also been made in the pupil study to analyse the importance of the teacher for the pupils' knowledge and proficiency, attitudes towards and opinions of IMU. The latter point could only be investigated for one-class pupils, but has revealed some rather interesting correlations between, for example, the teacher's qualifications and the pupils' attitude towards IMU. The teacher's attitude also seems in some cases to be of significance for what the pupils feel about IMU. In the latter case only one variable from the teacher data has been used as the basis for categorization. Many others exist and one approach would be to select from the teacher data very positive--very negative teachers and see what (if anything) the teacher's attitude means for all the pupils in the class. Thus this would be a question of extreme group studies of the same type as have in fact been used, but starting from other variables. Detailed studies could be made of attitude to the material, to the method: if the teacher is negative/positive to the material, do the pupils then also become negative/positive etc.? It has emerged that the teacher in no way becomes uninportant when the pupils work with self-instructional material, but that his/her tasks and perhaps also relationship with the pupils partially change. In the same way it would be interesting to study the composition of the teacher teams. At an early stage when the choice of design variables was being discussed, hopes were expressed of its being possible to investigate what having positive and negative teachers in a team can imply. Can a negative teacher, for example, "harm" the work of a team more than a positive one can "benefit" it? There are methodological and psychological problems in making such analyses, but it would be possible to carry out some, expecially in the teacher teams that have

remained unchanged during a reasonably long period. Teacher teams and the composition of teacher teams are definitely subjects of great importance and not something that should be seen as being merely associated with IMU—on the contrary, the changed forms of activity that are being tried out in the Swedish schools bring them to the fore. They could in that case also be expanded to include analyses of the psychological, educational and social effects that working in a teacher team lead to for the teachers, a subject that has been touched upon in the section on the changed role of the teacher.

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Appendix

Contents of appendix

Principles followed in compiling the appendix

In this section a brief summary will be given of the results obtained in the different part-studies. There are three main sub-sections: I. Pupil results, which comprises the main investigation's pupil study, the goal testing study, the material study and the study of anxious pupils; II. Teacher and assistant results, which comprises the main investigation's teacher and assistant study and the job analysis study and III. Other results, which comprises the parent study, the observation study, the studies of different ways of presentation, the project consultant activities and study of single pupils.

The reliability of the data and the way in which the data have been analysed is stated for each study. It is also stated for each study which report(s) the results are taken from.

When the list of "that" clauses was compiled the following principle was followed, taken from the main investigation. All variables are taken up under the heading "Total level". All variables for which there are differences between groups, are described under each main characteristic. The same principle has, as far as possible, been followed in the lists from the other part-studies.

I.1 Pupil results—main investigation (Larsson & Larsson, 1972, Larsson, 1972a)

I.1.1. *Reliability of data*

The pupil results include achievement data, questionnaire data and attitude data. The achievement data consists of marks in mathematics, standard tests in mathematics and Swedish and special IMU tests. For all the pupil data, the results have been analysed on the basis of material that has been adjusted for non-response to 100 per cent. The effect of the adjustments of non-response has been checked with regard to distributions, means, standard deviations,

correlations and ω^2 values. In no case has the use of the completely non-response-adjusted material been at risk. Non-response in data has been analysed from the point of view of the pupils' standard of knowledge and the organizational model in which they have worked. There is no system in the non-response. Estimations of reliability have been carried out on all the pupil data. The reliability varies between 0.52 and 0.76 for the achievement tests (Cronbach's α-coefficient) and between 0.26 and 0.98 for the questionnaire and attitude items (product moment correlations). Analyses made of the pupils' initial knowledge and attitudes show that the group of IMU pupils taking part when the experiment started were a representative random sample of grade 7 pupils in the autumn of 1968. Analyses of the pupils' organizational milieu during the experimental period show that the changes made were so extensive that the data for each term have been analysed separately.

Discussion of the differences between groups of pupils is based on the size of ω^2, that is to say, on how large a part of the total variance an average difference represents. All the pupil data have been analysed via $p \times q$ factorial ANOVAs.

I.1.2. *Data processing*

Analyses of data have been carried out in three main areas: pupil characteristics, milieu characteristics and teacher characteristics. In the $p \times q$ factorial ANOVAs, group affiliation constitutes factor A (two random samples of pupils have been used) and factor B one of the following:

Pupil characteristics

Factor B	*Levels*
1. marks in mathematics, gr. 6	3: marks 1 and 2; mark 3; marks 4 and 5
2. marks in Swedish, gr. 6	3: marks 1 and 2; mark 3; marks 4 and 5
3. intelligence, numerical factor, N	3: low group; middle group; high group
4. intelligence, spatial factor, S	3: low group; middle group; high group
5. intelligence, verbal factor, V	3: low group; middle group; high group
6. intelligence, reasoning factor, R	3: low group; middle group; high group
7. choice of course	2: general course; special course
8. school motivation	3: high; medium; low
9. anxiety	3: high; medium; low
10. use of mathematics	2: great use; fairly great use/neither great nor little use/fairly little use/very little use
11. enjoyment of mathematics	3: very/rather little; neither little nor great; fairly/very great
12. difficulties with mathematics	3: very/rather difficult; neither difficult nor easy; rather/very easy
13. sex	2: boy; girl

Milieu characteristics

Factor B	*Levels*
1. organizational model	3: large-class with 3 or more classes; large-class with 2 classes; one-class
2. assistant help	4: large-class with assistant: large-class without assistant; one-class with assistant; one-class without assistant
3. room arrangement I	2: large-class in one room: large-class in several rooms
4. room arrangement II	3: large-class in one room; large-class in several rooms but less than one teacher per class; large-class in several rooms and one teacher per class
5. locality of school	4: Stockholm, Gothenburg, Malmö: other towns with more than 50,000 inhab.; towns with 10,000–40,000 inhab.; towns with less than 10,000 inhab.
6. size of chool	4: ≥60 school points; 50–59.5 school points; 40–49.5 school points; ≤39.5 school points. (School points form the basis for government grants to the school. the larger the points the larger the school)

Teacher characteristics

Factor B	*Levels*
1. teacher's attitude towards IMU	2: (for autumn term '68): positive; uncertain and negative
	3: (for spring term '69 and st '70): positive; neutral; negative
2. work load as experienced by teacher	3: low; medium; great
3. teacher's age	3: born 00—29; 30—39; 40–47
4. teacher's qualifications	3: elementary school teacher; subject teacher with degree; others (student teachers/supply teacher/engineers/army officers/technologists)

The same applies for all the variables apart from the achievement variables, that both the total pupil group (TOTAL LEVEL) and the three main areas are summarized. In the case of TEACHER CHARACTERISTICS, only one-class pupils are included.

I.1.3. *Achievement variables*

In the analyses of marks distribution standard tests and IMU tests, it emerged

Pupil characteristics

that pupils belonging to the high group (marks, intelligence) reach the best results in the tests and acquire the highest term marks, pupils belonging to the low group achieve the worst results in the tests and acquire the lowest term marks

that pupils choosing the special course achieve better results than pupils choosing the general course

that the pupils' degree of school motivation does not produce any differences in the results

that in certain tests the least anxious pupils achieve the best results, the most anxious achieve the worst

that there are no differences in the results of boys and girls

that the pupils' convictions about the usefulness of mathematics do not affect the results

that in certain tests the pupils who enjoy mathematics achieve the best results, the pupils who find it boring the worst

that in certain tests the pupils who find mathematics easy achieve the best results, the pupils who find mathematics difficult the worst.

Milieu characteristics

that no difference in achievement are found in analyses of the pupils' milieu.

Teacher characteristics

that in some tests pupils with elementary school teachers achieve the best results

that the teacher's attitude towards IMU, the teacher's work load and the teacher's age do not lead to any differences in the pupils' achievements.

I.1.4. *General attitude variables*

In analyses of the pupils' more general attitudes towards school and mathematics it emerged

Total level

that on an average the pupils agree that they would do better in mathematics if they made a little more effort

that on an average the pupils are doubtful as to whether they would normally prefer to do something other than mathematics

that on an average the pupils agree that they would do better at school if they made a little more effort

that on an average the pupils are doubtful as to whether they are dissatisfied with their school marks

that on an average the pupils are not particularly anxious

that on an average the pupils do not have a particularly high school motivation

that no changes in the respects given above have taken place during the experimental period.

Pupil characteristics

that for certain variables the pupils' status with regard to knowledge at the start produces differences, as do their school motivation and their attitudes towards mathematics.

Milieu characteristics

that irrespective of the internal and external milieu in which the pupils work, their attitude is the same.

Teacher characteristics

that the characteristics of teachers studied produce few differences between the groups of pupils.

I.1.5. *Attitude towards school subjects*

In the analyses of the pupils' attitudes towards five school subjects, it emerged

Total level

that on an average the pupils find the subjects Swedish, English, physics and mathematics neither boring nor enjoyable, while the subject physical training was on an average thought to be rather enjoyable

that on an average the pupils find all the subjects except physics rather useful, physics is not felt to be either useful or useless

that on an average the pupils find all the subjects except physical training neither easy nor difficult, physical training is felt to be rather easy

that the attitudes of the pupils did not change during the experimental period.

Pupil characteristics

that in certain subjects there are differences between groups of pupils in that the pupils with the best initial knowledge and the most positive attitude found these subjects easiest and most enjoyable

that boys prefer physics and girls English.

Milieu characteristics

that the attitude of the pupils is independent of which internal or external milieu they are working in.

Teacher characteristics

that the characteristics of the teacher produce a few differences that are very difficult to interpret.

I.1.6. *Attitude towards the IMU material*

In the analyses of the pupils' attitude towards the IMU material, it emerged

Total level

that on an average the pupils consider the number of diagnostic tests and prognostic tests to be acceptable

that on an average the pupils find the written text in the booklet rather easy to neither easy nor difficult to understand

that on an average the pupils find the booklets neither boring nor amusing

that the attitude of the pupils did not change during the experimental period.

Pupil—milieu—teacher characteristics

that the attitude of the pupils is independent of characteristics of the pupils themselves, their milieu and their teacher.

I.1.7. *Attitude towards the IMU method*

In the analyses of the pupils' attitude towards the IMU method, it emerged

Total level

that on an average the pupils had accustomed themselves to work individually after a few weeks

that on an average the pupils rather enjoy working on their own, although this enjoyment decreased somewhat towards the end of the experimental period

that on an average the pupils find the work done during lessons rather varied during the first term, later neither monotonous nor varied to rather monotonous

that on an average the pupils find the work during mathematics lessons somewhat more monotonous than during other lessons

that on an average the pupils say that they work as hard during mathematics lessons as during other lessons

that on an average the pupils find the independent work rather useful

that on an average the pupils participate in group-teaching once a month, but would like on an average to participate a little less than once every other week

that on an average the pupils ask for help at least once a week and get help after waiting a few minutes

that on an average the pupils want as many oral explanations by the teacher as they in fact get and want to give oral accounts of what they have learnt in mathematics to the same extent as they do it

that on an average the pupils consider that the teacher checks their work

sufficiently often and makes personal contact with them during the mathematics lessons sufficiently often

that on an average the pupils work together with fellow-pupils for about an hour a month and want to work together from somewhat more to the same amount of time as now

that on an average the pupils want to work by themselves all the mathematics lessons a week save one

that on an average the pupils work a little more than half an hour a week at home

that when the pupils are asked to state what happened the last time they chose a new booklet (spring, grade 8), 63 per cent say that they chose it themselves, 23 per cent after having spoken to the teacher, while 28 per cent say that the teacher chose it, 6 per cent after having discussed with the pupil.

Pupil characteristics

that pupils in the low group (marks) and pupils choosing the general course ask for help more often than other groups of pupils

that in other respects the attitude of the pupils towards the method is the same.

Milieu characteristics

that the attitude is the same irrespective of the internal and external milieu in which the pupils work.

Teacher characteristics

that characteristics of the teacher produce only few differences between the groups of pupils.

I.1.8. *Attitude towards the IMU milieu*

In the analyses of the pupils' attitude towards the IMU milieu, it emerged

Total level

that on an average the pupils find it rather easy to concentrate during mathematics lessons during the first term, but later find it from neither difficult nor easy to rather difficult

that on an average the pupils find the discipline in class during the mathematics lessons neither good nor bad and neither better nor worse than during other lessons (though with a tendency towards worse)

that on an average the pupils say that they are disturbed occasionally when other pupils talk to each other or when other pupils receive help from the teacher(s)

that on an average the pupils find having two lessons running suitable sometimes, but not particularly suitable in grade 8.

Pupil characteristics

that irrespective of their ability and interest, the attitude of the pupils is the same.

Milieu characteristics

that the locality of the school is of significance for what the pupils feel about the discipline in the class during mathematics lessons compared with during other lessons but that otherwise the internal and external milieu produces no differences between groups of pupils.

Teacher characteristics

that the teacher's attitude towards IMU, the teacher's age and the teacher's qualifications produce certain differences between groups of pupils.

I.1.9. *Attitude towards course content*

In the analyses of the pupils' attitude towards the course content, it emerged

Total level

that on an average the pupils find the course neither boring nor enjoyable, though rather enjoyable in the beginning

that on an average the pupils find the course sufficiently difficult

that on an average the pupils think that they have considerable use of what they learn in mathematics in other subjects.

Pupil characteristics

that the greater the school motivation of the pupils, the more they enjoy the course

that in other respects the characteristics of the pupils produce no differences.

Milieu—teacher characteristics

that irrespective of the internal and external milieu the pupils work in and irrespective of the characteristics of the teacher, the attitude is the same.

I.1.10. *Attitude towards IMU in general*

In the analyses of the pupils' more general attitudes towards IMU, it emerged

Total level

that on an average the pupils are neither particularly satisfied nor particularly dissatisfied with their marks in mathematics

that pupils who are dissatisfied with their marks give as the main reasons that they do badly in tests, that the results of their work are bad and that their marks are low

that pupils who are satisfied with their marks give as the main reasons that they do well in tests, that they get the prognostic tests as soon as they have finished a module

that 92 per cent of the pupils say that they want to continue with IMU after one term, 83 per cent want to continue with IMU after two terms and 72 per cent want to continue with IMU after three terms

that 2 per cent definitely did not want to continue with IMU after one term, 5 per cent after two terms and 8 per cent after three terms

that on an average the pupils think that mathematics became neither more enjoyable nor more boring between the autumn and spring terms in grade 7, but that mathematics was somewhat more enjoyable in grade 7 than in grade 6 and neither more boring nor more enjoyable in grade 8 than in grade 7.

Pupil characteristics

that the higher the pupils' marks had been at the start, the more satisfied they were with their marks

that in other respects characteristics of the pupils did not produce any differences.

Milieu characteristics

that irrespective of internal and external milieu, the attitude of the pupils is the same.

Teacher characteristics

that pupils whose teacher was an elementary school teacher wanted more than the others to continue with IMU and thought more than the others that mathematics was more enjoyable in grade 7 than it had been in grade 6

that in other respects characteristics of the teacher did not produce any differences between the groups of pupils.

I.2. Pupil results—goal testing study (Hellström, 1972b)

I.2.1. *Reliability of data*

The goal testing study was carried out in the spring of 1971 when the pupils were in grade 9. Since the pupils were working in accordance with the cur-

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riculum of 1962 (though not with regard to the course content), the population of the study was limited to the IMU pupils who were in the mathematics streams in grade 9. All the pupils, 8600, have been tested. The number of goal testing tasks is approximately 700. Most of these have been tested in written tests, distributed in such a way that each task has been tested on about 120 pupils. Some of the 700 tasks were such that they were considered to require special measures when being tested, so they have been tested in special tests (78 tasks altogether). For this purpose a random selection was made from 30 classes. Other tasks were such that it was necessary to test them orally. This applied to 43 tasks, which were tested on 120 pupils altogether, randomly selected from the population. A certain amount of non-response occurred in each type of test. Analyses of the non-response show a certain degree of association with particular schools. The non-response is not systematic with regard to the pupils' marks in mathematics from grade 6. The test tasks have been corrected by two independent assessors. There is a satisfactory degree of agreement in both the written and oral tests.

1.2.2. *Data processing*

The data have been analysed both as a whole, and in accordance with the characteristics of the pupils: sex, choice of course and marks in mathematics from grade 6, plus the type of organizational model the pupils belonged to: large-class – one-class. The frequencies of the answers have been calculated both in actual numbers and in relative frequencies expressed as percentages of the number of pupils who have received a particular task. Differences between the groups have been tested by means of χ^2 tests for two or more independent random samples. The level of significance has been set at 0.01. For some tests, where the total number of points constitutes a numerical variable (written special tests), the data have been treated by single-factorial ANOVA, in which ω^2 on 0.05 or above has been taken as indicating essential differences between the groups. In the analyses, tasks (tests) that test knowledge have been differentiated from those that test proficiency within each of the material areas that are defined in the goal descriptions of the IMU project.

1.2.3. *Results*

When the total average percentage of correct answers per task were put together for each area of the material, it emerged for the written terminal tests that the average percentage of correct answers and the lowest (min.) and highest (max.) percentage of correct answers for any one task within the area of the material was:

		average	min.	max.
Sets	knowledge	41	1	96
Numbers	knowledge	25	2	94
	proficiency	56	0	95
Statements, simple	knowledge	37	4	93
logic	proficiency	40	2	90
Powers	knowledge	40	4	87
	proficiency	41	0	80
Units	knowledge	67	31	98
	proficiency	68	25	95
Algebra	knowledge	19	3	46
	proficiency	15	0	51
Tables	proficiency	42	21	64
Theory of function	knowledge	24	0	92
	proficiency	20	0	75
Geometry	knowledge	32	0	99
	proficiency	40	0	98
Descriptive statistics	knowledge	27	1	78
	proficiency	43	6	74
Theory of probability	knowledge	6	0	14
	proficiency	36	5	64
Approximate values,	knowledge	16	0	67
rough estimates	proficiency	33	0	70
Percentages	knowledge	42	4	77
	proficiency	50	11	87
Problems	proficiency	26	3	77

that no difference occurred in the percentage of correct answers as a result of division according to sex or organizational model

that pupils who have chosen the special course consistently achieve a higher percentage of correct answers

that pupils with high marks from grade 6 achieve a higher percentage of correct answers than pupils with low marks

that if the standard of achievement stated in the goal descriptions of the IMU project is applied, the majority of the total percentages of correct answers will fail to reach this standard

that most of the pupils were at the end of grade 9 working with module 9, component B, and were therefore acquainted with the various fields of the material that were tested.

When the average number of correctly answered tasks in the written special tests were put together it emerged

that the total average number of correctly answered tasks in a test on *mental arithmetic* was 15.6 out of a possible 21

that pupils choosing the special course and pupils with high marks in mathe-

matics from grade 6 achieve better results in this test than pupils choosing the general course and with low marks in grade 6

that girls do better than boys in this test

that the total average number of correctly answered tasks in two tests on *the use of the slide-rule* was 6.4 and 3.1 out of a possible 10

that for one of the tests there are differences between special-general course, between the groups with different marks and between the organizational models. In the two first cases special course pupils and pupils with high marks achieve better results, in the latter case one-class pupils achieve better results than large-class pupils

that for the second test there are differences between special-general course, between the groups with different marks and between boys and girls. The two first cases imply the same as above, the latter that boys achieve better results than girls

that the total average number of correctly answered tasks in a test on *the ability to use mathematical formulas* was 2.3 out of a possible 6

that there are differences between special-general course and between the groups with different marks with the same import as above and between girls and boys with the import that boys achieve better results than girls

that the total average number of correctly answered tasks in a test on *the ability to use tables* was 5.6 out of a possible 14

that there is a difference between special-general course and between the groups with different marks with the same import as above

that the total average percentage of correct answers for tests in the ability to make *rough estimates* and assessments varies between 93 and 17 (seven tasks)

that there are differences between special-general course and between the groups with different marks with the same import as above

that the total average percentage of correct answers in a test in the ability *to draw geometric constructions* with help of a pair of compasses and a ruler varies between 47 and 1 (10 tasks)

that the total average percentage of correct answers in certain tests that were carried out orally was

		average	min.	max.
Longimetry	knowledge	34	1	81
Slide-rule	knowledge	27	1	74
	proficiency	73	47	90
Algorithms	knowledge	47	26	69
Geometry	knowledge	50	2	92
Rapid-counting techniques	knowledge	19	0	26

I.3. Pupil results—material study (Larsson, 1972c, Davidsson, 1972)

I.3.1. *Reliability of data*

The material study has been carried out on a sample of IMU pupils. The principle of selection is the date of birth: pupils born on the 15th of any month are included. The schools have sent in these pupils' diagnostic and prognostic tests, which have been corrected within the project, and questionnaires on which the pupils have given their opinions on the booklets and on individual items in the booklets. The non-response is about 4—5 per cent for data from grades 7 and 8, about 8—10 per cent for data from grade 9. The three versions of the prognostic test that exist for each module have in the analyses proved to be parallel, with the exception of the test paper for module 9.

I.3.2. *Data processing*

The data have been analysed for the total group of pupils and for groups of pupils divided according to the following design variables: the pupils' marks in mathematics in the spring term of grade 6, choice of course, sex and school motivation. The data are given descriptively, only in exceptional cases has statistical hypothesis testing been carried out. All the analyses have been done for each booklet, separately.

I.3.3. *Results*

In the analyses of the data, it emerged

- that there is no connection between the speed with which the pupils work through the material and their achievements measured in the results of the prognostic tests. There are quick and proficient, quick and less proficient, slow and proficient and slow and less proficient pupils
- that the pupils who have worked on the higher levels (2—3, 3) of the B and C components have on an average the best results in the tests
- that there is a connection between choice of level and marks from grade 6 in that the pupils with high marks in particular chose the higher levels, while pupils with low marks in particular chose the lower levels
- that the pupils' attitude to the booklets is on an average said to be "neither difficult nor easy" and "neither boring nor enjoyable" respectively
- that pupils with high marks in mathematics from grade 6 on an average achieve better results in diagnostic and prognostic tests than pupils with low marks
- that pupils choosing the special course achieve better results in diagnostic and prognostic tests than pupils choosing the general course

that there are no differences between boys and girls in the results of the diagnostic and prognostic tests, nor in their opinions about the booklets and the items in the booklets

that the degree of the pupils' school motivation is of little significance for their results in diagnostic and prognostic tests or for their opinions about the booklets and the items in the booklets

that the material can be said to have functioned satisfactorily in the respects stated above for high-achievement pupils, but not altogether satisfactorily for low-achievement pupils.

I.4. Pupil results—study of anxious pupils (Petterson, 1972)

I.4.1. *Reliability of data*

The study includes two part-studies. The first concerns the groups of IMU pupils and control pupils that participated in the main investigation. Thus the reliability tests that were carried out in the latter also apply to the part-study concerning anxious pupils: the same material has been used with partly different analysis techniques.

The other part-study includes altogether 96 pupils in grades 3, 6 and 9 in the Malmö schools that during the school year 1970/71 were not working with IMU. The pupils have been selected from a total of 24 classes. The non-response is negligible. The data have been gathered both via questionnaires that were offered in writing to all the pupils in the 24 classes (the material for the 96 pupils was extracted afterwards) and via interviews with the 96 pupils.

I.4.2. *Data processing*

The data from the first part-study have been processed via a $3 \times 2 \times 2 \times 2$ factorial ANOVA, where the factors are achievement (five achievement variables have been used), sex, group affiliation (IMU-control group) and repetition of the measurement variables, anxiety and school motivation. The repetition refers to two measurements: at the start of grade 7 and at the end of grade 8.

The data from the other part-study have been processed via both single and multiple factorial ANOVAs. For both part-studies the level of significance has been set at 0.01. The summary of the results given below first starts from this level of significance, and then from another criterion for difference, namely the measurement of effect ω^2 dealt with earlier. (Both criterions are used in the original report.)

I.4.3. *Results*

In the analyses of the data from part-study I, it emerged (with the significance criterion)

that there is a difference between the groups with different marks in that pupils with lower marks in mathematics have less school motivation than pupils with higher marks

that pupils with low-achievement in the numerical, spatial and verbal factors have less school motivation than pupils with higher achievement

that there is change towards less school motivation between grade 7 and grade 8

that IMU pupils with the lowest marks (marks in mathematics) change less than other IMU pupils, while control pupils with the lowest marks change more than the other control pupils in the respect named above

that pupils with lower marks in mathematics are more anxious than pupils with higher marks in mathematics

that pupils with low achievement in the numerical, verbal and logical factors are more anxious than pupils with high achievement in the respective factors

that boys are less anxious than girls

that the pupils are less anxious in grade 8 than in grade 7

that pupils with lower marks in mathematics change more to becoming less anxious than pupils with higher marks

that pupils with low achievement in numerical and verbal factors change more to becoming less anxious than pupils with high achievement

that IMU pupils change more than control pupils towards being less anxious.

In the analyses of data from part-study I, it emerged (with the ω^2 criterion)

that there is a change towards less school motivation from grade 7 to grade 8

that pupils with lower marks in mathematics are more anxious than pupils with higher marks in mathematics

that pupils with lower achievement on the verbal factor are more anxious than pupils with higher achievement on the factor.

In the analyses of data from part-study II, it emerged (with both the significance criterion and the ω^2 criterion)

that the attitude towards mathematics is more positive in the lower grades than in the higher ones

that pupils in lower grades are more school motivated than pupils in higher grades

that high-achieving boys have a more positive attitude towards mathematics than low-achieving boys in grade 6

that high-achieving boys are less anxious in test situations than low-achieving boys.

II.1. Teacher and teacher assistant results—main investigation (Larsson & Larsson, 1972, Larsson 1972b)

II.1.1. *Reliability of data*

The teacher and teacher assistant data consist of answers to questionnaires. Non-response for the entire questionnaire from the teachers is 4.8, 9.5 and 7.9 per cent for the occasions autumn term '68, spring term '69 and spring term '70 respectively. Non-response has been analysed with regard to the teachers' organizational affiliation: whether they work in three-class, two-class or one-class models. In this respect the non-response is not systematic. Non-response for the entire questionnaire from teacher assistants on the same measuring occasions is 3, 8 and 4 per cent. It has not been possible to carry out reliability estimations of the questionnaire data. Analyses of the organizational milieu and of moves among teachers show that changes have taken place to so great an extent that the data for each term has been analysed separately.

II.1.2. *Data processing*

The main part of the teacher data has been analysed via $p \times q$ factorial ANOVAs. Analyses have been carried out in two main fields: teacher characteristics and milieu characteristics. The teachers' organizational affiliation has been used as a constant factor as above, with one of the below as the second factor:

Teacher characteristics	*Levels*
1. age	3: born 00–29; 30–39; 40–47
2. qualifications	3: elementary school teacher; subject teacher with degree; others (student teachers/supply teacher/engineers/mil. officers/technologists
3. sex	2: man; woman
4. experience of IMU	2: experience; no experience

Milieu characteristics	*Levels*
1. locality of school	4: as for pupils
2. size of school	4: as for pupils
3. assistant	2: assistant; no assistant
4. room arrangement	2: as for pupils (room arrangement 1)
5. room arrangement/teacher density	4: large-class in one room, less than one teacher/class; large-class in several rooms, less than one teacher/class; large-class in one room, one teacher/class; large-class in several rooms, one teacher/class

The starting point for discussion of differences between the groups is the size of ω^2 in accordance with what applied for the pupil results in the main investigation. The teacher study is, however, a population study.

The assistant data have been analysed after division according to organizational affiliation: works in three-class, two-class or one-class models or in two or more combinations of the above. Only absolute answer distributions have been extracted.

II.1.3. *Time for preparation and complementary work*

In the analyses of the amount of time said by the teachers to be needed in connection with IMU teaching, it emerged

Total level

that during an average week the teachers used about 165 minutes in the first term and about 190 in the second and third

that this time was divided between the following tasks (asterisk denotes that the alternatives were not given)

	at '68	st '69	st '70
teacher team conferences	36	38	39
planning of group teaching	13	*	11
planning of tutoring of pupils	14	10	9
correction of tests	26	27	27
keeping pupil statistics	11	8	7
handling material	10	10	8
reading ahead in pupil booklets	34	24	17
study of method manual etc.	19	14	10
checking booklets	*	11	10
working out supplementary material	*	4	6
listening to tapes	*	3	2
setting marks	*	10	9
instruction of staff	*	3	3
information to parents	*	4	4
head of department tasks	*	5	5
contact teacher tasks	*	3	3
class teacher duties	*	8	11
visits	*	2	2
IMU project	*	7	5

Teacher characteristics

that the division of working time does not vary as a result of age, qualifications, sex or experience of IMU teaching.

Milieu characteristic

that if there is a teacher assistant the time taken by the teacher for correction and keeping pupils statistics diminishes

that visits and demonstrations occur predominantly in large towns

that the frequency of conferences increases with the size of the school

that checking of the pupils' booklets occurs most at the second to smallest schools

that conference work in large-class teams takes more time the lower the teacher density is

that planning of tutoring and working out supplementary material occurs more often the lower the teacher density is

that the time needed for handling material, correcting diagnostic tests, keeping pupil statistics, visits and demonstrations increases if the teacher density is 1 teacher/approx. 30 pupils.

Organizational model

that the time needed for more administrative tasks is longer for one-class teachers

that the time needed for conference work is higher for large-class teachers.

II.1.4. *Tasks during lessons*

In the analyses of the amount of time said by the teachers to be needed for work during lessons, it emerged

Total level

that the lesson time was on an average divided between the following tasks

	at '68	st '69	st '70
individual tuition	63 %	55 %	52 %
group teaching	10	8	9
class teaching	*	3	4
handling material	8	5	4
keeping pupil statistics	3	2	2
class teacher duties	2	1	1
correction of tests	7	3	3
supervision	6	6	8
consultation with others in teacher team	*	2	2
moving between classrooms	*	3	3
individual tasks with pupils	*	2	1
supervision of tests	*	3	2
wasted time	*	1	1
presentation for new pupils	*	1	1
visits	*	1	*
work with the D component	*	4	4

Teacher characteristics

that the division of working time does not vary as a result of age, qualifications, sex or expericene of IMU.

Milieu characteristics

that if there is an assistant the time needed by the teacher for administrative tasks diminishes

that higher teacher density in a large-class team leads to longer time being needed for handling material, keeping pupil statistics and correction of diagnostic tests.

Organizational model

that one-class teachers devote more time to administrative tasks

that large-class teachers devote more time to group teaching

that large-class teachers devote more time to consultation with others and to supervision duties.

II.1.5. *Estimation of time-consumption of different tasks*

In the analyses of the teachers' estimation of whether the time they have to spend on different tasks is too great, satisfactory or too little, it emerged

that the tasks that lay outside lesson-time took on average a satisfactory amount of time

that handling of material, moving between classrooms and supervision during lessons took too great a proportion of the time

that too small a proportion of the lesson-time could be devoted to group teaching and class teaching.

II.1.6. *The teachers' attitude towards method, material, organization (large class) and the IMU system in the form they themselves have used*

In the analyses of the teachers' attitude in the respects stated above, it emerged

Total level

that on an average the teachers are rather positive to individualized teaching in mathematics, rather positive to version 3 of the IMU material, neutral with a leaning towards negative to the large-class organization and neutral to the IMU system in the form that they themselves use.

Teacher characteristics

that the attitude does not vary as a result of age, qualifications, sex or experience of IMU.

Milieu characteristics

that large-class teachers who work in one room and in teacher teams of 1 teacher/class are negative to this form of the IMU system

that otherwise the teachers' external and internal milieu does not affect their attitude.

Organizational model

that the attitude is the same irrespective of the organizational model the teachers work with.

II.1.7. *The effects of the IMU system on the teachers' work-situation*

In the analyses of the teachers' attitude in the respects stated above, it emerged

Total level

that to some extent the teachers agree that the IMU system makes them more stressed, which to some extent is felt to be a disadvantage

that the work-load of the teacher increases somewhat without this being felt to be a disadvantage

that teaching with IMU is compared to conventional teaching somewhat more monotonous for the teacher without this being felt to be a disadvantage

that the teacher's work-situation deteriorates somewhat with IMU without this being felt to be a disadvantage.

Teacher characteristics

that the attitude to the effects of the IMU system on the teacher does not vary as a result of age, qualifications, sex or experience of IMU.

Milieu characteristics

that in the questionnaire given in spring 1969 there were only differences for a few variables between large-class teachers, such as that large-class teachers who work in one room in a teacher team of 1 teacher/class find the teaching more monotonous than the others and find that the teacher's tasks become less qualified than the others consider them to be.

Organizational model

that one-class teachers think to a greater extent than others that their work-load increases

that in the questionnaire given in spring 1970 one-class teachers think to a lesser extent than others that the teacher's tasks become more qualified with IMU.

II.1.8. *The teachers' attitude towards the IMU material*

In the analyses of the teachers' attitude towards the IMU material, version 3, it emerged

Total level

that the number of diagnostic tests was considered to be just right

that the number of prognostic tests was considered to be less in IMU than in conventional teaching, which was felt to be a disadvantage.

Teacher—milieu characteristics

Organizational model

that the attitude to the material does not vary as a result of characteristics of the teacher, milieu or organization.

II.1.9. *The teachers' attitude towards cooperation between teacher and pupil*

In the analyses of the teachers' opinions on the possibility of cooperation between teacher and pupil, it emerged

Total level

that the teachers' opportunities of checking the pupils' work neither increase nor decrease with IMU

that the social contact between teacher and pupil is neither better nor worse with IMU

that the number of direct contacts between teacher and pupil increase somewhat with IMU, which is felt to be to some extent an advantage

that the teacher can devote more time to the individual pupil with IMU, which is felt to be an advantage

that cooperation between teacher and the individual pupil in planning the teaching is neither better nor worse

that weak pupils are somewhat more dependent on the ability of the teacher with IMU

that clever pupils are less dependent on the ability of the teacher, which is felt to be an advantage

that pupils need wait a neither longer nor shorter amount of time for help with IMU.

Teacher characteristics

that the attitude does not vary as a result of the teacher's age, qualifications, sex or experience of IMU.

Milieu characteristics

that the teachers in the second largest towns consider that the teacher's op-

portunities for checking the pupils' work diminish somewhat, that there is less social contact between teacher and pupil, that the number of direct contacts diminishes, that the pupils have to wait longer to get help—all these differences only in the measurement of spring 1970.

Organizational model

that teachers working in one and two-class models consider to a greater extent than three-class teacher that the number of direct contacts increases, that the teacher can devote more time to the individual pupil.

II.1.10. *Cooperation between pupils*

In analyses of the teachers' attitude towards cooperation between pupils with IMU, it emerged

Total level

that the number of direct contacts between pupils neither increases nor diminishes

that cooperation between pupils is less intensive with IMU.

Teacher—milieu characteristics

Organizational model

that the attitude does not vary as a result of the characteristics of the teacher, his/her milieu or the organizational model.

II.1.11. *IMU's effect on various groups of pupils*

In the analyses of the teachers' attitude towards IMU's effect on various groups of pupils, it emerged

Total level

that weak pupils work under neither greater nor lesser pressure with IMU

that the teaching is hardly better adapted for the weaker pupils

that the weaker pupils possibly get rather less support with IMU, which is felt to some extent to be a disadvantage

that the weaker pupils become somewhat more passive with IMU, which is to some extent a disadvantage

that the average pupils get teaching which is neither more nor less well-adapted to their needs

that the teaching is better adapted for the clever pupils which is felt to be a clear advantage

that the clever pupils become more active with IMU, which the teachers consider to be an advantage.

Teacher characteristics

that the attitude does not vary as a result of the teacher's age, qualifications, sex or experience of IMU.

Milieu characteristics

that the locality and size of the school is of some significance for isolated variables on isolated measurement occasions, as is the room disposition of the large-class teacher.

Organizational model

that the attitude does not vary as a result of the organizational model.

II.1.12. *The pupils' work-situation as a whole*

In the analyses of the teachers' opinions on the pupils' work-situation in the IMU system, it emerged

Total level

that IMU makes greater demands on the pupils' ability to take initiative than conventional teaching

that the pupils learn to take responsibility to a greater extent with IMU, which is thought to be an advantage

that the teaching is somewhat more monotonous for the pupils with IMU, which is considered a disadvantage

that the mistakes made by the pupils are possibly corrected somewhat later with IMU

that the pupils' chances of remedying weaknesses increase with IMU

that a continual following-up of the pupils' achievements is easier with IMU, which is thought to be a slight advantage

that the pupils get less homework with IMU

that the school work is possibly more tiring with IMU

that the pupils' work-situation is, however, neither better nor worse with IMU

that there are no differences in learning effects between IMU and conventional teaching

that the risk of learning incorrectly is thought to increase somewhat with IMU, which is felt to be a disadvantage.

Teacher characteristics

that teachers with academic degrees consider that the pupils' work-situation becomes somewhat worse with IMU.

Milieu characteristics

that large-class teachers who work in one room with less than 1 teacher/class

consider more than others that the risk of learning incorrectly increases with IMU.

Organizational model

that the attitude does not vary as a result of the organizational model.

II.1.13. *The formal treatment and the oral explanation*

In the analyses of the teachers' attitude towards the formal treatment and the pupils' oral performance, it emerged

Total level

that the formal treatment is thought to be worse with IMU than in conventional teaching, which is considered to be a disadvantage

that the pupils get less training in speaking mathematics, which is seen as a disadvantage

that the pupils get considerably less training in understanding oral accounts of mathematics, which is seen as a disadvantage.

Teacher—milieu characteristics

Organizational model

that the attitude as given above is the same irrespective of the characteristics of the teacher, milieu or organizational model.

II.1.14. *Cooperation with other subjects, disciplinary problems*

In the analyses of the teachers' attitude towards the opportunities for cooperating with other subjects and to disciplinary problems in IMU teaching, it emerged

Total level

that IMU makes cooperation with other subjects somewhat more difficult, but this is thought to lack significance

that disciplinary problems increase somewhat with IMU, which is thought to be a slight disadvantage.

Teacher characteristics

that the attitude does not vary as a result of the teacher's age, qualifications, sex or experience of IMU.

Milieu characteristics

that teachers who teach in towns next in size to the three largest cities find to a greater extent than others that disciplinary problems increase.

Organizational model

that the attitude does not vary as a result of the organizational model.

II.1.15. *Reasons for pupils getting behind in the material*

When the teachers were given the opportunity of stating what they thought were the primary reasons for the fact that some pupils could not keep up a normal rate of study of 3 modules per school year, it emerged

Total level

that the pupils' inability to work independently was noted most

that this was followed by an inability to concentrate, insufficient intelligence, difficulties in reading and writing, lack of interest in mathematics and laziness during lessons

that reasons connected with the teachers and their opportunities for hurrying along the pupils who work slowly and with circumstances in the pupils' environment were noted very seldom.

II.1.16. *Desired and actual teacher density*

In the analyses of spring 1970 in grade 8, it emerged

that the desired teacher density in different types of organization that the teachers had had experience of was

large-class with assistant	32 pupils/teacher
large-class without assistant	23 ,,
one-class with assistant	30 ,,
one-class without assistant	24 ,,

that the desired teacher density in different organizational models that the teacher did not have experience of was

large-class with assistant	33 pupils/teacher
large-class without assistant	24 ,,
one-class with assistant	31 ,,
one-class without assistant	22 ,,

that the desired teacher density is thus connected with the existence of an assistant, in that on an average the teachers consider that they can tutor approximately 10 additional pupils if they have the help of a teacher assistant

that the actual teacher density in spring 1970 in grade 8 was

4 classes with assistant	34 pupils/teacher
4 classes without assistant	33 ,,
3 classes with assistant	35 ,,
3 classes without assistant	33 ,,

2 classes with assistant	34	pupils/teacher
2 classes without assistant	34	,,
1 class with assistant	29	,,
1 class without assistant	27	,,

that thus large-class teachers working with the help of an assistant have in their own opinion the desired number of pupils, large-class teachers working without the help of an assistant have approximately 10 pupils too many to tutor, that one-class teachers with an assistant have the number of pupils that they consider as a maximum, while one-class teachers without an assistant have a few too many pupils to tutor

that in interpreting the word "desired", it should be noted that the question was worded: How many pupils per teacher do you think is a maximum for the teaching with the IMU-material to function properly.

II.1.17. *The teacher assistants' tasks during and outside lessons*

In the analyses of the teacher assistants' tasks during and outside lessons, it emerged

that the majority of the assistants carry out a number of tasks connected with handling material both during and outside lessons

that the assistants have a series of contacts with the pupils and their work

that personal contacts with the pupils mainly occur during lessons

that contacts with the pupils' material occur predominantly outside lessons, if they do not at the same time lead to contacts with the pupils themselves

that the assistants' contacts with the teacher occur predominantly outside lessons in connection with conference work

that most assistants take part in conferences

that the assistants to a very little extent handle contacts with the pupils' homes

II.2 Teacher and teacher assistant results—the job analysis study (Alchammar & Klasson, 1972a, b)

II.2.1. *Reliability of data*

The job-analytical study has been carried out in two stages. The first consists of an interview study with a selection of people whose jobs involve them with IMU teaching. The other consists of a questionnaire study carried out on all heads of departments, teachers and assistants who during the school year 1970/71 worked with IMU in grades 8 and 9, using versions 3 and 4 (identical versions) of the IMU material.

Data from the first stage have been categorized in a system of main cate-

gories closely associated with the headings in method manual. Checks have been made in order to standardize both the interview methods and the analyses of the interview material.

The second stage has been based on data from the interviews, which have been structured into seven main categories and which have been analysed in six aspects. The questionnaire study is a population study. Non-response for the entire questionnaire from the teacher group is 17 per cent. 10 per cent of non-response from the teacher group can, taking into consideration known reasons for non-response, to some extent be feared to be systematic. Non-response for the entire questionnaire from the assistant group is 7 per cent. Internal non-response occurs. This has been analysed with regard to the category of job. No systematic non-response has been proved in this respect. There is correlation between some of the design variables that have been used for analyses.

II.2.2. *Data processing*

Processing of data from the interviews comprises categorization of the collected material in 'that' clauses, which within their respective main categories provide qualitative job descriptions for the teachers concerned.

Processing of data from the questionnaire section has been carried out mainly via single-factorial ANOVA, in which altogether eight different design variables have been used as shown below:

Design variables	*Levels*
1. Type of job	3: head of department; teacher; teacher assistant
2. Organizational model	3: three-class; two-class; one-class
3. Composition of teacher team	4: 1 t. without assistant; 1.5 ts. with assistant; 2 ts. with assistant; 2.5 ts. with assistant
4. Level of education	3: elementary school teacher; teacher with academic degree; others
5. Size of school	3: ≤30.5 school points; 31–44 school points; ≥44.5 school points
6. Town–country	4: central city area; suburban city area; town area; country district
7. Development of pupil population	3: drastically diminished number of pupils; largely constant number of pupils; drastically increasing number of pupils
8. School locality	4: Stockholm, Gothenburg, Malmö; towns with over 50,000 inhab.; towns with 10,000–49,000 inhab.; towns with less than 10,000 inhab.

Designs 2—8 include only heads of department and teachers. The measuring variables consist of 60 situations divided into seven main categories: exchange

of information, teacher team conferences, introduction of pupils, teaching of total group, group teaching, measurement of achievement and registration/office routine. All 60 situations have been assessed in six aspects: occurrence, actual/desired relative work required, cooperation, difficulty and stimulation.

As a starting point for the discussion of differences between the groups has been taken the size of ω^2 in accordance with what applied to the main investigation's teacher and assistant study.

II.2.3. *Results of the job description*

In the analyses of the interview material for the job descriptions, it emerged

that school principals and heads of department are primarily responsible for introducing the system to members of the teacher team and training them

that among the members of the teacher team the assistants are those who primarily feel the need for training in both mathematics and educational psychology

that school principals and heads of department are primarily responsible for the exchange of information with parents and with official bodies and persons outside their own school

that teacher team conferences are included in both the teachers' and the teacher assistants' duties

that the work situations with which these conferences are predominantely concerned involve the formal organization of preparatory work, execution and supplementary work

that the teacher team conferences are most often led by the head of department

that teacher team conferences are considered positive

that training pupils in the IMU system has occupied relatively few work-situations

that it is mainly teachers who work with the training of pupils, in the form of working with the booklets and with the technique of studying

that pupils who move can create problems with regard to the training of pupils

that total group teaching, which includes individual tutoring, has collected most work-situations from the members of teacher teams

that the working time of the teachers is primarily concerned with individual tutoring, and that of the assistants with the handling of material

that difficulties arise when it is necessary to arrange group teaching

that the tasks of the assistants in connection with group teaching primarily concern administrative arrangements

that the assistants are the category that have stated most situations connected with measurement of achievement, that is to say tasks involving correc-

tion of tests, supervision and the handling of material

that in connection with the measurement of achievement the teachers primarily mention correction of tests, setting of marks and the organization of measuring achievement

that the assistants have reported most situations within the category registration, office routine and handling of material, while the teachers have only stated a few situations within this category.

II.2.4. *Results from the evaluation questionnaire*

In the analyses of the questionnaire concerning the statements made by the members of the teacher team about the teaching and the desired organizational model, it emerged

that a certain amount of increase in the amount of teaching hours occurs, usually arranged so that the clinic teacher or some other remedial teacher comes to the teaching unit, more seldom that the pupils are outside the unit during the lesson

that the desired organizational model consistently entails increased teacher density

that the participation of a teacher assistant is considered so valuable that those using the one-class model also wish to have the help of an assistant.

In the analyses of the occurrence of the different work-situations for the various members of the teacher team (design 1), it emerged

that the heads of departments meet the various situations to a greater extent than the others, irrespective of the main category

that the ranking with regard to situations within each respective main category that the members of the teacher team meet is

	head of dept.	teacher	assist.
exchange of information	6 (least)	6	6
teacher team conference	5	5	4
training of pupils	2	3	5
total group teaching	1 (most)	1	3
group teaching	4	4	7
measurement of achievement	3	2	2
registration/office routine	7	7	1

that thus heads of department and teachers state principally that they meet work situations involving total group teaching, preparatory training of pupils and measurement of achievement, while the assistants state principally that they meet situations involving registrations/office routine, measurement of achievement and total group teaching

that in the other designs (2--8), only a few essential differences appear between the different groups. Those that exist occur mainly in divisions according to organizational model and the composition of the teacher team.

In the analyses of the other five aspects (actual and desired relative amount of work, cooperation, difficulty and stimulation) over the various situations within the seven main categories, the following emerged for the heads of department/teachers and teacher assistants respectively:

that the largest relative amount of work for the teachers lay within the main category total group teaching, and the largest for the assistants within the main category registration and office routine

that teachers wish to increase the amount of work primarily for the main category group teaching and decrease it for registration and office routine

that cooperation occurs principally within the main category teacher team conferences and group teaching for the teachers, while cooperation occurs within almost all the main categories for the assistants

that for the teachers none of the main categories cause great difficulties but that above all registration/office routine causes small or no difficulties and that the pattern is the same for the assistants

that for the teachers the teaching categories provide stimulation in their work, while registration/office routine does not provide any stimulation and for the assistants it is particularly the teacher team conferences and the work situations within these that provide little or no stimulation.

In the analyses of the same data within the other seven designs, which include only the teacher group, it emerged

that in the designs involving the teachers' qualifications, the size of the school, the school's situation in town/country, the development of the pupil density and the school's locality, few essential differences have been measured

that in the designs involving the organizational model and the composition of the teacher team, relatively more essential differences have been measured

that for the design organizational model that includes three-class, two-class and one-class, it can be said that most of the essential differences that exist between the three models lie within the aspect cooperation, implying that one-class teachers have essentially fewer opportunities than others of cooperating in teaching and administrative situations

that for the design teacher team's composition, which includes 4 groups (1 teacher without assistant = one-class, 1.5 teachers with assistant = two-class, 2 teachers with assistant = three-class and 2.5 teachers with assistant = three-class), it proved that the majority of the essential differences

that were measured lie within the aspect cooperation, implying that one-class teachers without an assistant have to a considerably less extent opportunities for cooperating in teaching and administrative situations

that one-class teachers without an assistant often have a greater actual amount of work within the category registration/office routine

that the teacher density in three-classes has some significance for the possibility of cooperating within the main category registration/office routine

that situations within teacher team conferences are felt to be less stimulating by two-class teachers than by others.

II.2.5. *Summary of results from the two part-studies within the job-analytical study*

The following summarized conclusions (without internal ranking) can be drawn from the results in the two part-studies

that although completely different techniques were used for both data collection and data processing, no essential differences can be found that lead to contradictory interpretations of the results

that the work in teacher teams has not yet got properly into its stride everywhere, but the opportunities for cooperation are in themselves largely felt to be positive

that when it comes to large-class teaching the teachers express a clear desire for additional time, in order to be able to gather the groups for going through points together

that when it comes to individual tutoring in the large-class, far too much time must be spent on keeping the class quiet

that the opportunities for organizing and finding staff for group teaching varied greatly

that there was a common desire to arrange more group teaching

that the group teaching seemed to provide the teachers with opportunities for variation and stimulation that can be particularly important in a system of the IMU type, which has extreme individualization and self-instruction

that the role of the head of department as supervisor and contact man is an important factor in the IMU system

that the assistants to a large extent relieve other members of staff of routine administrative tasks

that the assistants in many cases participate in the direct tutoring of the pupils

that the assistants are to a very great extent responsible for correction and compilation of diagnostic tests but also participate in the correction of prognostic tests

that being an adult working closely with the pupils the assistant also complements the teachers in motivating and supporting the pupils and helping them if they have personal problems

that the assistants feel a need of training, particularly in dealing with the pupils, in being introduced into the organization and working methods of the school and in mathematics.

III.1. Parent study (Larsson, 1972d)

III.1.1. *Reliability of data*

The data comprises answers to a questionnaire that was sent to parents during the spring and summer of 1970. These were parents to pupils working with version 3 of the IMU material during the school years 1968—71 and who were born the 15th of any month. The questionnaire was sent to 364 parents and answers were received from 347 or 95.6 per cent. Those answering are mother (32.9 per cent), father (53.3 per cent), both parents (3.8 per cent), other guardian (2.0 per cent). For 8.1 per cent the status of the respondent is not given.

III.1.2. *Data processing*

Analyses of the parents' answers have been carried out both for the total group, and for sections divided according to certain characteristics in the pupils. These are the pupils' course/marks in mathematics in the spring in grade 8, sex, class affiliation (large-class—single-class) and the pupils' school motivation. As the starting point for interpretations has been taken the size of Cramér's index, which should be at least 0.22 if a difference is to be considered essential.

III.1.3. *The parents' answers*

In the analyses of the questionnaire data, it emerged

that 87 per cent of the parents knew about IMU when they received the questionnaire

that 58 per cent of the parents had received their information about IMU from their son/daughter,
16 per cent through information from the school,
24 per cent through both son/daughter and the school and
2 per cent from some other source

that 32 per cent of the parents said that they did not know anything about

the new content in the mathematics, the knowledge of the remainder ranged from a little to everything

that 27 per cent had received information about the new content by reading their son/daughter's booklets
36 per cent from what their son/daughter told them
20 per cent from information from the school
7 per cent from IMU's information booklet
7 per cent from radio and television
2 per cent from newspapers and
2 per cent from some other source

that the higher the marks of a pupil in mathematics, the more often the parents had got information by reading the booklets

that the greater the school motivation of the pupil, the more often the parents had read IMU's information booklet

that 78 per cent of the parents find individualized mathematics teaching good or very good
12 per cent neither good nor bad and
6 per cent bad or very bad

that 5 per cent of the parents consider that the children have too much homework in mathematics, the others from just the right amount to none at all

that 40 per cent of the parents are positive to the large-class in mathematics teaching
22 per cent are neutral
30 per cent are negative and the rest can or will not state an opinion

that parents of pupils that go in large-classes give fewer negative answers on the question of the large-class than one-class pupils' parents

that the boys' parents are less negative towards the large-class than those of the girls

that 27 per cent of the parents can help their children with mathematics if it involves the new content

that 59 per cent can help their children with mathematics if it involves the old content

that 44 per cent of the pupils never ask for help with the new content and
30 per cent of the pupils never ask for help with the old content

that the higher the marks a pupil has in mathematics, the less often he asks for help

that 10 per cent of the parents think it is easier,
37 per cent that it is more difficult and
25 per cent that it is neither more difficult nor easier to help the children with mathematics than with other subjects

that 14 per cent of the parents think that the pupils do better in mathematics than in other subjects,

57 per cent that they do as well and
21 per cent that they do worse

that the lower the marks the pupils have in mathematics, the more often their parents say that they do worse or that they cannot state an opinion

that 54 per cent of the parents think that today's school is better than the school they themselves went to
15 per cent think it is worse and
19 per cent do not want to state an opinion

that the most important reasons why today's school is better are the teaching methods and the content of the teaching,
the most important reasons why today's school is worse is the teaching milieu.

III.2. Observation study (Martinsson, 1972)

III.2.1. *Reliability of data*

The observation study has been carried out in 8 schools in all, of which 7 are in Malmö or in the neighbourhood of Malmö, 5 are IMU schools, that is to say, are included in the effect investigation's population of schools, 3 are schools which do not have IMU or any other self-instructional material in mathematics. The organizational milieu within the schools taking part in the effect investigation has been so varied that it has not been possible to make any random samples of schools. Instead schools that have used some of the more frequent organizational models have been chosen: IMU one-class without assistant, IMU two-class with teacher team of 1.5 teachers and assistant, IMU three-class with teacher team of 2 teachers and assistant, in which the teaching is done in one large room, and IMU three-class with teacher team of 3 teachers and assistant, in which the teaching is carried out in several classrooms. Three schools in Malmö that work conventionally, that is to say, with 1 teacher, 1 class, 1 classroom and a conventional textbook, have been used as control schools.

There have been five observation periods during the school year 1969/70, at which three observers have been used. The agreement between the observers for both pupil, teacher and assistant observations is satisfactory for the main categories of the schedule, while there is some less satisfactory agreement for individual sub-categories.

III.2.2. *Data processing*

The data treatment is based on the addition of markings for each main and sub-category. For some categories single-factorial ANOVA has been carried

out. Essential differences are considered to be those in which ω^2 is greater than or equal to 0.10. Processing has been carried out for the groups' control classes, IMU one-class, IMU two-class and IMU three classes.

III.2.3. *Results—pupils*

In the analyses of the pupils' activities during the mathematics lessons, it emerged

that the distribution over four main categories for the four pupil groups was: (the average number of markings taken over five observation periods)

	control	one-class	two-class	three-class
individual mathematics	108	117	117	86
interactive mathematics	42	17	15	12
individual non-mathematics	17	36	30	48
interactive non-mathematics	20	20	10	35

that thus the pupils spend the main part of the lesson working on their own irrespective of the type of class

that IMU three-class devotes more time to non-mathematical activities than the other pupils

that the proportion of interactive mathematics is higher for the control group, which is a result of the fact that class teaching occurs more frequently in this group

that the proportion of group teaching is small in the IMU classes and does not occur at all in the control classes

that of the activities that occur during individual mathematics, the majority come under "read, write, draw, count" for all the pupil groups

that of the activities that occur during interactive mathematics "look at or listen to teacher" is the most frequent

that of the activities that occur during interactive non-mathematics "conversation with classmate" is the most frequent in all pupil groups.

III.2.4. *Results—teachers*

In the analyses of the teachers' activities during the mathematics lessons, it emerged

that the distribution over six main categories for the four teacher groups was: (average number of markings taken over the five observation periods)

that thus the control class teachers and two-class teachers devote more time to teaching than the others and less time to the other activities

	control	one-class	two-class	three-class
teaching	128	96	124	96
administration	10	27	14	18
supervision	22	23	5	14
disciplinary measures	3	2	1	8
conversation	1	3	8	5
other activities	30	48	29	47

that taken as a whole the activity of the teachers during lessons can be ranked as follows from high to low frequency for the four groups:

Non-IMU: individual tutoring, other activity, class teaching. Group teaching does not occur.

IMU one-class: other activity, individual tutoring, group teaching, class teaching.

IMU two-class: individual tutoring, other activity, group and class teaching.

IMU three-class: individual tutoring, other activity, group and class teaching.

Tutoring in groups does not occur in any of the organizational models.

III.2.5. *Results -assistants*

In the analyses of the assistants' activities during the mathematics lessons, it emerged

that the distribution over six main categories for the two assistant groups (assistant in two-class and assistant in three-class) was. (average number of markings taken over five observation periods)

	two-class	three-class
teaching	8	21
administration	84	94
supervision	1	2
disciplinary measures	1	2
conversation	10	9
other activities	83	67

that thus the assistants mainly devote their time to administrative tasks during lessons and to other activities that include checking the pupils' work, arranging moves in and between rooms and other oral and non-oral activities

that the assistants only teach to a slight extent and that when it does occur it is primarily a question of individual tutoring of pupils and instructions to pupils.

III.3. Studies of different ways of presenting mathematical material (Berglund & Jivén, 1968, 1969, Jivén, 1971)

III.3.1. *Reliability of data*

All three reports describe studies that have been carried out on pupils who do not normally work with IMU material. In several studies matching procedures have been used, in a further few, classes have been picked at random from certain school districts in Malmö. In all the studies parts of the IMU material have been used, particularly from the first modules and the material has been treated in different ways. The studies comprise pupils from corrective reading classes, remedial classes and normal classes in grades 4, 5, 6 and 7. The duration of the study has been short for all the studies.

III.3.2. *Data processing*

The techniques for treating the data vary for the different studies. In some ANOVA has been used, in others non-parametric methods.

III.3.3. *Results*

In the analyses of the effect of the step-size on achievements in post-tests, it emerged (remedial classes, grade 7)

that pupils working with material with smaller step-sizes achieve better results on post-tests, but that these pupils work longer and solve more problems during this work.

In the analyses of the effect of the step-size and the effect of the means of presentation (machine—book) on achievements in post-tests, it emerged (remedial classes, grades 5 and 6)

that when the step-size is held constant with large steps, machine presentation requires more time than book presentation, but no difference can be found between book presentation and machine presentation in the results of the post-tests

that when the step-size is held constant with small steps, machine presentation requires more time than book presentation, but in the final post-test machine presentation gives better results than book presentation

that when the means of presentation is held constant to book presentation,

small steps require more time than large steps, but small steps produce better results in post-tests

that when the means of presentation is held constant to machine presentation, small steps require more time than large steps, but small steps produce better results in post-tests

that the best combination of presentation and step-size appears to be machine presentation with small steps if one disregards the time consumption.

In the analyses of visual and auditory presentation of the mathematics course, it emerged

that no differences exist between visual and auditory presentation with regard to achievements in post-tests (corrective reading class, grades 4 and 6, reading clinic, grade 4)

that pupils who have worked with oral presentation achieve better results on problems in the exercise book but that no differences can be found in the results of post-tests (remedial classes, grades 5 and 6)

that oral presentation takes longer than written but that in post-tests there are no differences between oral and written presentation (normal class, grade 7).

III.4. Project consultant activities (Olsson, 1972a)

III.4.1. *Reliability of data*

The report concerning the activities of the project consultants does not give an account of a study in the same way as the other part-studies within the effect investigation do. It presents the tasks and experiences of the project consultants during the two years that they worked with the project. The report is based on the visiting diaries that the consultants handed over to the project after each visit to a school.

III.4.2. *Data processing*

In the context of what has been said above, it should be pointed out that there has been no real processing of data—what processing there has been has consisted more of systematization of the information from the two years under certain main headings.

III.4.3. *Results*

The tasks that have primarily occupied the consultants have concerned being responsible for maintaining contact with the schools participating in the pro-

ject by means of personal visits, telephone and letter contact, for catching impulses and currents from the experimental schools and forwarding them to the project, the authors of the material and the National Board of Education. It has also been the task of the consultants to present the IMU project at teachers' seminars and at schools of education, to present and represent the project with contacts abroad, to function as experts at meetings and "hearings" concerning the project. The consultants have also had to devote rather a lot of time to what have been called single pupils, that is to say, see that the pupils who move from experimental schools with IMU to other schools that do not have IMU are not handicapped from having participated in experimental teaching. This last point has been all the more important since the IMU pupils up to 1970 studied a different syllabus in mathematics than other pupils in grades 7–9.

The consultants themselves have found their work both rewarding and stimulating and have also experienced that the schools have benefited from their contribution. From the point of view of the project this link between the project leaders and the experimental schools has been extremely valuable.

III.5. Study of single pupils (Olsson, 1972b)

III.5.1. *Reliability of data*

The data comprises answers to questionnaires handed out to pupils who have moved from IMU experimental schools to another school where IMU is not used, and answers to questionnaires that have been given to these pupils' new teachers. Questionnaires sent out on two occasions are reported: spring 1970 when pupils in all the grades of the upper level school participated and spring 1971 when pupils from grades 8 and 9 participated. On both occasions there was some non-response of whole questionnaires. On the first occasion it was 8 per cent for pupils and 8 per cent for teachers, on the second 24 per cent for pupils and 14 per cent for teachers. On the second occasion the questionnaire was sent out late in the term. Both pupil and teacher studies have been counted as population studies, however.

III.5.2. *Data processing*

The main part of the processing of data has concerned the extraction of answer distributions for the different questions in the questionnaires. In the case of the pupils, comparisons are made between the grades in the last questionnaire. Some comparisons are also made with data obtained in the main investigation's pupil study.

III.5.3. *Results*

In the analyses of answers from the pupil questionnaires, it emerged

that a single pupil more often sits and works in the same classroom as the other pupils than in a separate room

that despite this the single pupil feels little disturbance

that the majority of the pupils consider that they have no trouble in working with a different mathematics course than their classmates, although it goes less well in grade 9

that the pupils ask their teacher for help rather seldom

that the pupils consider that the teachers comes to see them suitably often

that in general the pupils find the working method (working on their own) fun

that the pupils are satisfied with the opportunities for giving accounts orally

that the pupils in grades 7 and 8 find their work during mathematics lessons neither monotonous nor varied, while the pupils in grade 9 find it monotonous

that the pupils consider it useful to work independently in mathematics

that the delivery of material has on the whole functioned well as far as the pupils are concerned

that the majority of the pupils do not regret continuing with IMU after moving from the IMU experimental school, although 12 per cent of the pupils in grade 9 regret it

that the IMU material has attracted a certain amount of attention from others in the class so that at least one has expressed a desire to work with IMU

that the pupils are on the whole satisfied with their marks in mathematics

that the pupils work between half an hour and an hour a week at home.

In the analyses of answers from the teacher questionnaires, it emerged

that most of the teachers at least knew something about IMU before they got a single pupil in their class

that most of the teachers did not find it particularly burdensome to have one or more single pupils in their teaching unit

that a bare half of the teachers find it stimulating to have single pupils, the others find it not particularly or not at all stimulating

that the contacts established by the project leaders and the consultants have on the whole been satisfactory, that the information has been sufficient and that the material that was needed has arrived

that the teachers feel that it is rather easy to tutor single pupils and that the single pupils have only taken up a small part of the teacher's time. The reasons for this have been said to be primarily that the single pupils are clever and manage their work themselves, that the rest of the class claims all their time and that the material is so well-adapted for independent studies that the teacher does not need to intervene

that the teachers consider that the single pupils in general make good progress, but that their intellectual status is the same as the average pupil's

that arrangements with single pupils should preferably occur in grade 9

that the teachers themselves would like to see a textbook of the conventional type or material that is self-instructional, though to a lesser degree than IMU, used at their own school in grade 7 the following year.

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